VOL. VII. APRIL, 1899.

Established by BENJAMIN SILLIMAN in 1818.

THE

AMERICAN JOURNAL OF SCIENCE.

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FOURTH SERIES.

VOL. VII—[WHOLE NUMBER, CLVII.]

No. 40.—APRIL, 1899.

WITH PLATES VI–VII.

NEW HAVEN, CONNECTICUT.

1899.

TUTTLE, MOREHOUSE & TAYLOR, PRINTERS, 125 TEMPLE STREET.

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THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XXV.—*Glacial Lakes Newberry, Warren and Dana, in Central New York;* by H. L. FAIRCHILD. (With Plate VI.)

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Introduction.

THE ice sheet of the last glacial epoch covered, during its greatest extent, all the area of the Great Lakes. When the receding front of the waning glacier had passed to northward of the southern boundary of the Laurentian basin, the glacial and meteoric waters were impounded between the ice front and the north-sloping land surface. These glacial lakes had their outlets southward across the divide, and they expanded northward as the barrier of ice receded. The local lakes were gradually united by draining of higher levels to lower, and ultimately these glacial waters became of vast extent, exceeding in breadth and depth any existing lakes. Their shorelines have been found at many localities and traced for great distances and the romantic history and relationship of the glacial waters have become in recent years the subject of a special body of earth-science literature.

During the later phase of the Laurentian glacial waters, Lake Warren invaded central New York from the west, and drew down to its level the local waters of the Finger Lakes valleys. This region is of special interest, on account of its singular topographic character, and because it includes the critical locality where the great Warren waters found lower escape to the sea (than by the westward outlet to the Mississippi) and excavated in their flow toward the Mohawk a series of remarkable channels, piling the debris in great deltas in the more quiet waters of the intersected valleys.

The abandoned rock channels and correlating deltas are the most conspicuous features produced by the glacial waters. Southeast of Syracuse these great cuts in rock, some of them headed by cataracts, lie so close together that they cannot be represented satisfactorily upon the map (Plate VI). They are the last records of a lake history of truly dramatic interest. Their examination will repay not only the special student in geology and physiography, but the person having merely a general or casual interest in those sciences.

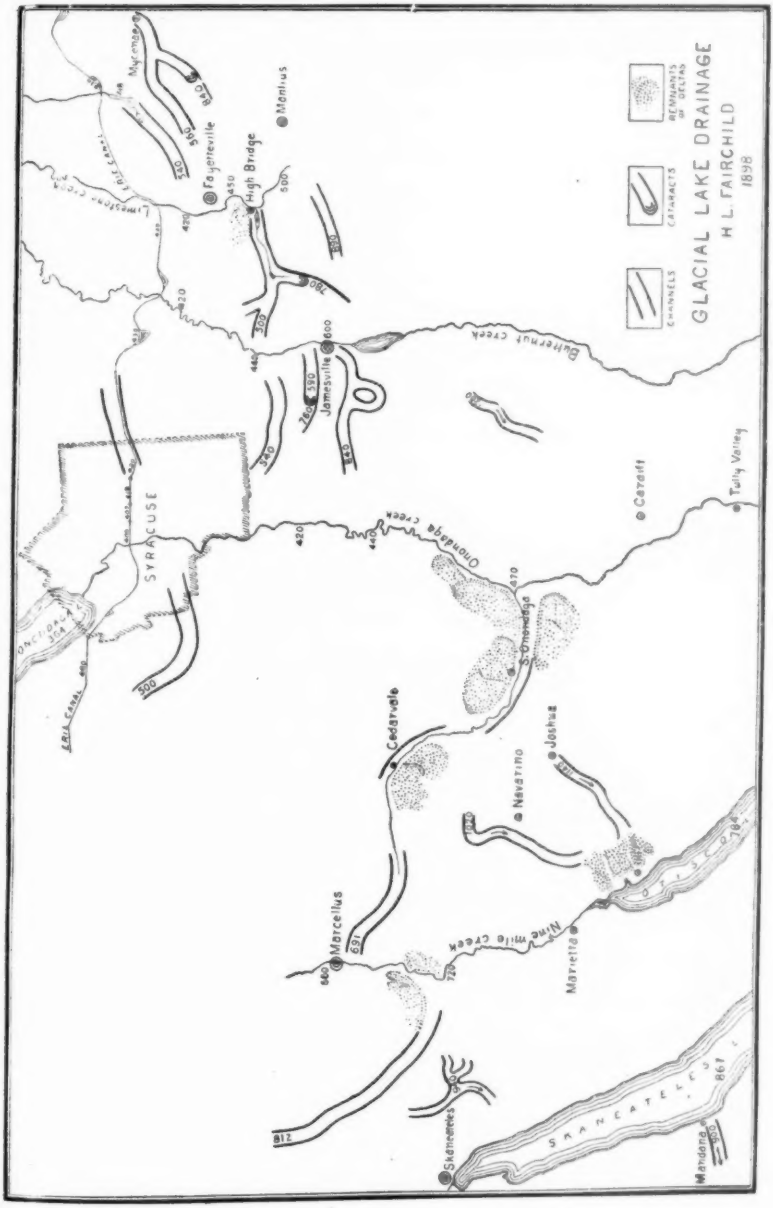
The study of the glacial lake phenomena in New York State has now been carried so far that the principal facts and relations in the history of those waters are known. It is the purpose of this writing to describe briefly the succession of events in the life and extinction of the later and broader glacial waters in the critical district of the Finger Lakes.

Description of the Maps, p. 251 and Plate VI.

The larger map locates in a generalized way the shorelines of the four greater glacial lakes, Newberry, Warren, Dana, and Iroquois.

The outlet of Lake Newberry was south to the Chemung River through the col (900 feet altitude) at the head of the Seneca Valley. The probable eastward limit of this water is indicated between Cayuga and Owasco Valleys, and the locality of its destructive drainage or lowering into Lake Warren is shown east of the north end of Canandaigua Lake.

The Warren waters found their first eastward escape southeast of Syracuse by either the channel west of Butternut Valley, with altitude 840 feet, or the one east of that valley with elevation 890 feet. (The channels are better shown on the smaller map.) The uncertainty as to the earliest spillway is indicated by the broken termination of the eastern end of the Warren shoreline. The most westerly of the hypo-Warren outlets is the one north of Skaneateles with elevation 812 feet. East of this channel is a series of channels which conveyed the overflow eastward to lower and lower levels.


GLACIAL LAKE DRAINAGE
H. L. FAIRCHILD
1898
CHANNELS
CATARACTS
REMNANTS OF DELTAS
Fayetteville
High Bridge
Manlius
Jamesville
SYRACUSE
Onondaga Creek
Butternut Creek
Tully Valley
Cedarvale
Navarino
Joshua
Marcellus
Nine mile Creek
Marietta
Skaneateles
Manlius
SKANEATELES L.

Lake Dana is a stage of the waters having their level determined by the outlet channel east of Marcellus, elevation 691 feet, with which the Dana shoreline terminates.

The several rock channels cut by the east-flowing waters in their escape to the Mohawk-Hudson lie so near together that they cannot be well represented on the larger map (Plate VI), but they are more clearly shown on the smaller map, p. 251.

The small circles on the larger map indicate cities or villages, the names of which are omitted to save confusion. On the smaller map the names are given.

The heavy broken line indicates the post-glacial divide between Laurentian and south-flowing waters. Bars drawn transverse to the water-parting indicate the location of outlets of the primitive local glacial lakes; those elsewhere on the map represent later outlets of secondary waters.

Numerals give elevations, in feet, above ocean level.

Physiography of the District.

The territory in general which includes the glacial lake phenomena described in this paper is that part of New York State known as the region of the "Finger" Lakes. Its more precise limitations are, on the west, the valley of Honeoye Lake and on the east a line somewhat beyond Syracuse. Those north and south valleys lying to the west of Honeoye, namely, Canadice, Conesus and the Genesee, were never related to the Newberry waters.

The accompanying map shows the hydrography of the present time. The topography will be sufficiently described, with the help of elevations given on the map, by stating that the area between Lake Ontario and the northern ends of the Finger Lakes is a plain of 400 to 600 feet elevation, while the north and south "Finger" Lake and intermediate valleys are preglacial trenches in an elevated tract of more enduring rocks. As far as the waning ice sheet upon the north left the land exposed, the northern and lower plain was covered by the Warren and Dana waters, which extended southward in a series of deep narrow bays up the valleys into the higher plateau. To the work of these lakes, with the subsequent Iroquois, is due the heavy silt deposits and the subdued topography of the lower part of this plain.

The ice movement, in the closing phase, followed the direction of the lake valleys, thus having a radial or spreading flow; and local lobes of the ice, or stream glaciers, protruded beyond the general ice front up each of the valleys, leaving in each valley a heavy moraine, which now constitutes the head of the present drainage, or the divide between north and south flow.

The ice was probably thicker in the deeper and broader valleys of Seneca and Cayuga, and the general direction of the retreating front of the great ice body was probably convex toward the south, and for our theoretical discussion may be regarded as normal to the axes of the divergent valleys.

Since the glacial lakes were drained the beaches have been thrown out of horizontal position by a differential northward uplift that has affected the entire Laurentian area. It is therefore evident that during the life of the glacial lakes the altitude of Central New York was much less than now, and that the depression was progressively greater toward the north or somewhat east of north.

Earlier Local Glacial Lakes.

As the front of the ice sheet melted back upon the north of the divide, the larger valleys in Central New York were occupied by important local lakes, which had their overflow across the divide into southern drainage. These lakes have been described with some detail in former papers by the writer.* For the present purpose it will be sufficient to enumerate the lakes and briefly state their location and relationship.

The glacial Honeoye occupied the valley of that name and sent its overflow into the Canandaigua Valley. At an earlier time the Honeoye Valley was flooded by the Canandaigua waters (Naples Lake).

The Naples Lake was the earliest glacial water in the Canandaigua Valley, with its outlet across the divide at the head of the valley, near Atlanta station. Subsequently a lower escape was found across the eastern border of the basin into the Flint Creek Valley and the waters became tributary to those in the Keuka Valley (Hammondsport Lake). This later phase of the Canandaigua waters is called the Naples-Middlesex Lake.

The Italy Lake occupied the upper Flint Creek Valley and overflowed at the head of the valley into Naples Lake. A lower stage of Flint Creek Valley waters, the Potter Lake, has not been fully studied at the time of this writing.

The Hammondsport Lake occupied the Keuka Valley. This valley had a lake history similar to that of the Canandaigua. The early phase of the Hammondsport Lake had its outlet south through Bath village. A later phase had its outlet across the eastern rim through the village of Wayne, but ultimately to the Cohocton Creek, like the earlier phase.

* Glacial Lakes of Western New York, Bull. Geol. Soc. Amer., vol. vi, p. 353; Genesee Glacial Lakes, ibid., vol. vii, p. 423; Lake Warren Shorelines in Western New York and the Geneva Beach, ibid., vol. viii, p. 269; Glacial Waters in the Finger Lakes Region of New York, ibid., vol. x, p. 27–68.

The Watkins Lake occupied the upper Seneca Valley with outlet at Horseheads to the Chemung River. This was the predecessor of Lake Newberry, the latter being simply the former lake widely expanded into the Cayuga and other valleys adjacent to the Seneca Valley. (See page 255).

The Ithaca Lake occupied the Cayuga Valley with an outlet southeast to Catatonk Creek and the Susquehanna River.

The Groton and Moravia Lakes occupied the Owasco Valley, the former being the primitive lake in the main valley with outlet at Freeville, the latter being the later and larger lake with lower outlet southwest; both stages being tributary to the Cayuga waters.

The first glacial Skaneateles, in the valley of that name, overflowed by the head of the valley past Scott village and Homer to the Tioughnioga Creek, but a later and much lower stage, called the Mandana Lake (from the name of its outlet) received the overflow of glacial waters of the Otisco and Onondaga Valleys, and had its outlet westward into the Warren waters, which then occupied the Owasco Valley.

The glacial Otisco overflowed at first southward past Preble village to the Tioughnioga Creek, but a later stage of the waters, the Marietta Lake, had outlet westward into the lower stage of the Skaneateles. At the foot of this valley, and also of the Onondaga and Butternut Valleys, we find the great channels and deltas, produced by the eastward flow of Warren and later waters, which are to be discussed in this paper.

The Cardiff Lake occupied the upper Onondaga Valley and overflowed through the site of the Tully Lakes to the Tioughnioga Creek. A later, lower lake in the middle section of the Onondaga, the south Onondaga Lake, had its outlet by two successive channels westward to the Marietta Lake in the Otisco Valley.

Butternut Valley was long occupied by a primitive glacial lake, called the Butternut Lake, with outlet near Apulia station to the Tioughnioga Creek below Tully village. When the valley was nearly clear of ice the glacial waters escaped for a time westward into the Onondaga Valley.

Eastward is still another north and south valley involved in this history, that of Limestone Creek. The earlier local lake phenomena have not been studied, but the lower (northward) part of the valley was occupied by the hyper-Iroquois waters and related to the great eastward-leading river channels.

In the eastern valleys, Skaneateles, Otisco, and Onondaga, the later glacial lake history is intricate and with surprising changes of drainage. It will be noted that the later, local glacial waters drained westward—those of the Butternut Valley into the Onondaga, the Onondaga into the Otisco, the

latter into the Skaneateles and this into the Owasco Valley, then occupied by the great Lake Warren. The westward-leading channels of these earlier waters are shown on page 251. When, however, Lake Warren found eastward escape, all these valleys were drained eastward with the lowering Warren or hyper-Iroquois waters.

Lake Newberry.

Origin.—The lowest of all the cols across the line of water-parting separating the present north and south drainage in New York is the one at Horseheads, the head of the Seneca Valley, with elevation of 900 feet. This great channel* is the final result of the erosion by the concentrated glacial drainage from the district lying between and including Honeoye Valley on the west and Owasco Valley on the east. Originally the channel carried only the overflow of the Watkins Lake and was doubtless somewhat higher than now, but the amount of the down-cutting has not been determined. The name "Watkins" lake applies to the waters as long as they were limited to the Seneca Valley. Lake Newberry may be regarded as having its birth when, by the recession of the ice front, the waters of either the Ithaca or the Hammondsport Lake were drained down to and became confluent with the Seneca Valley waters. Lake Newberry is therefore only the larger, more expanded Watkins Lake. The former name is used, not only as a matter of convenience but also for uniformity in glacial lake nomenclature; in order to distinguish the broad waters with complex relationship from the smaller, more localized, and simpler Watkins Lake.

Judging from the topography of the region, it seems more probable that the first local lake to lose itself in the Horseheads level was the Hammondsport. The locality of its overflow was probably near 2d Milo, four miles south of Penn Yan.

Extent and tributaries.—Upon the west, Keuka Valley became a gulf of the Newberry waters, first by the Penn Yan depression and later by the open valley to the north. Flint Creek Valley became a bay of the greater lake when the ice receded from the locality of Stanley and Gorham. The waters of Canandaigua and Honeoye Valleys were certainly tributary to the Hammondsport Lake through the Flint Valley, and probably continued tributary to the Flint Valley waters even after they were a part of Lake Newberry.

Upon the east, the Ithaca Lake found its close when the ice withdrew as far north as Ovid. The scourways made by the escaping Ithaca waters show an east and west erosion of the

* The Horseheads channel is described and figured in a former paper, Bull. Geol. Soc. Amer., vol. vi, p. 365.

drumlin surface in and south of Ovid village. In the Cayuga Valley the Newberry waters existed for a time sufficient to produce clear evidences of its presence, but as to Owasco Valley the evidence is negative. They may have existed there a short time, or the ice dam toward the Canandaigua Valley may have lifted and drained Lake Newberry before the removal of that which barred the Owasco waters. The earlier Owasco waters (Moravia Lake) were certainly tributary to Lake Newberry by the North Lansing-Ludlowville channel and probably were the easternmost of such tributary waters.

Lake Newberry certainly included the valleys of Flint Creek, Keuka, Seneca, and Cayuga Lakes, and possibly Owasco for a brief time. In form the lake was an east and west belt of water resting against the ice front, and with four deep bays reaching southward up the valleys above named. Its linear extent was considerable, and its shoreline great, but its total area was not large in proportion.

Shorelines and Elevations.—The phenomena of the Newberry shorelines have been observed, chiefly as terraces, and wave-built bars on terraces, of landstream deltas, throughout the Keuka and Seneca Valleys and in the southern part of the Cayuga Valley. These have all been described in detail in another writing* and it will be sufficient here to briefly mention the localities and altitudes.

In the Seneca Valley the Newberry shore phenomena have been measured at many localities; at the head of the valley between Odessa and Montour Falls (Havana), 935 to 940 feet; at Montour Falls, 950 feet (aneroid). On the west side, at Watkins, 960 feet; at Himrods, 990 (?) feet (aneroid); at Stanley 970 feet. Between Reed's Corners and Ennerdale occur the channels which drained the lake to the Warren level, 985 feet to 930 feet (aneroid). On the east side of the valley are good delta ridges at Burdett, 964 feet; at Hector's Station, 976 feet; at North Hector Station, 984 feet; at Lodi, 977 feet. At Ovid the level is in the village, but the exact elevation is undetermined.

In the Cayuga Valley well-defined beach ridges occur at Trumansburg, 962 feet elevation. No effort has been made to locate the shore phenomena at other points, but they can undoubtedly be found throughout the valley.

In Keuka Valley the main delta terraces throughout the valley are 955 to 970 feet elevation, and are attributed to Newberry waters.

The northward rise of these altitudes is evident and measurable, but the matter of beach deformation will not be discussed in this paper.

*Glacial Waters in the Finger Lakes Region of New York, Bull. Geol. Soc. Amer., vol. x, p. 27–68.

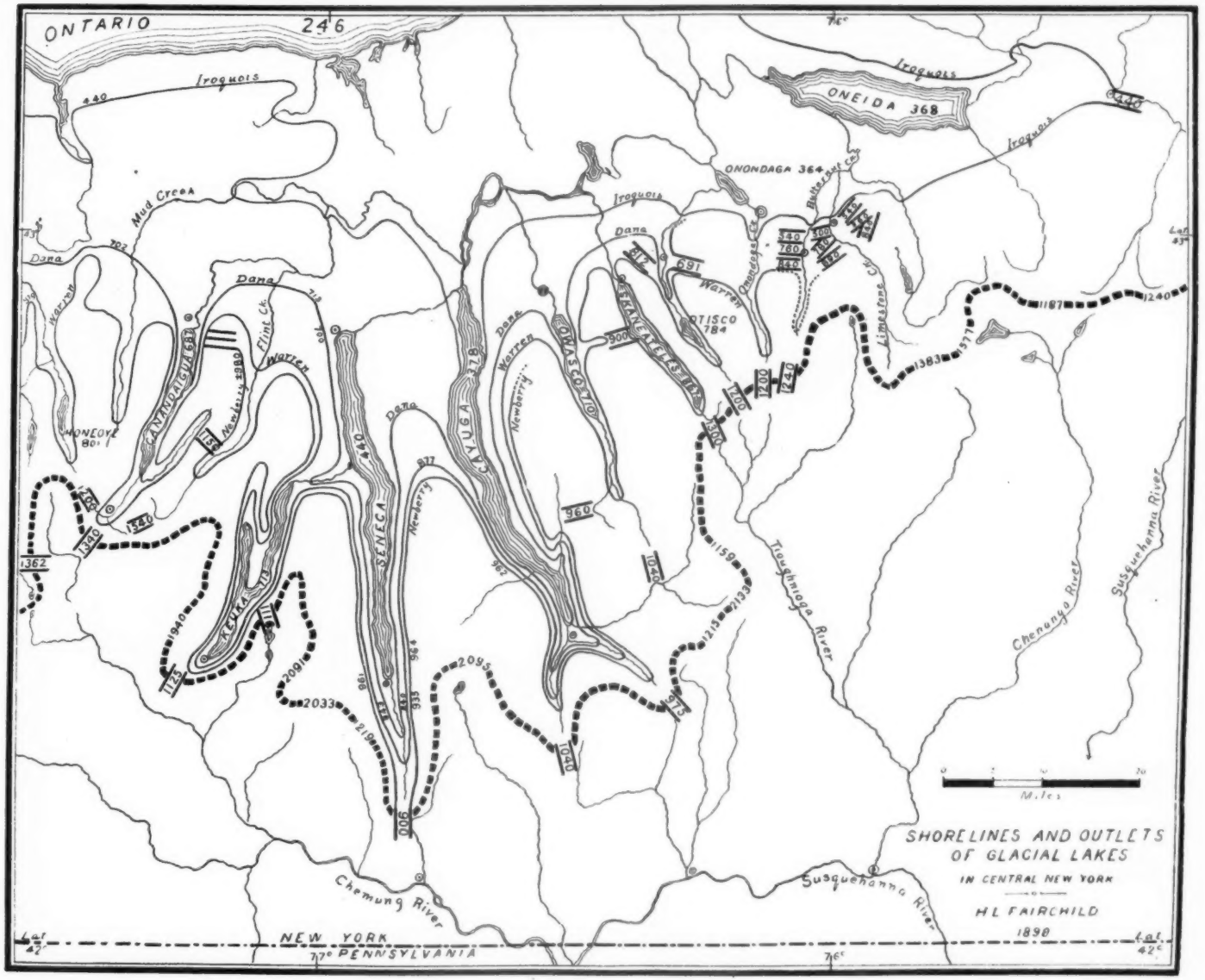
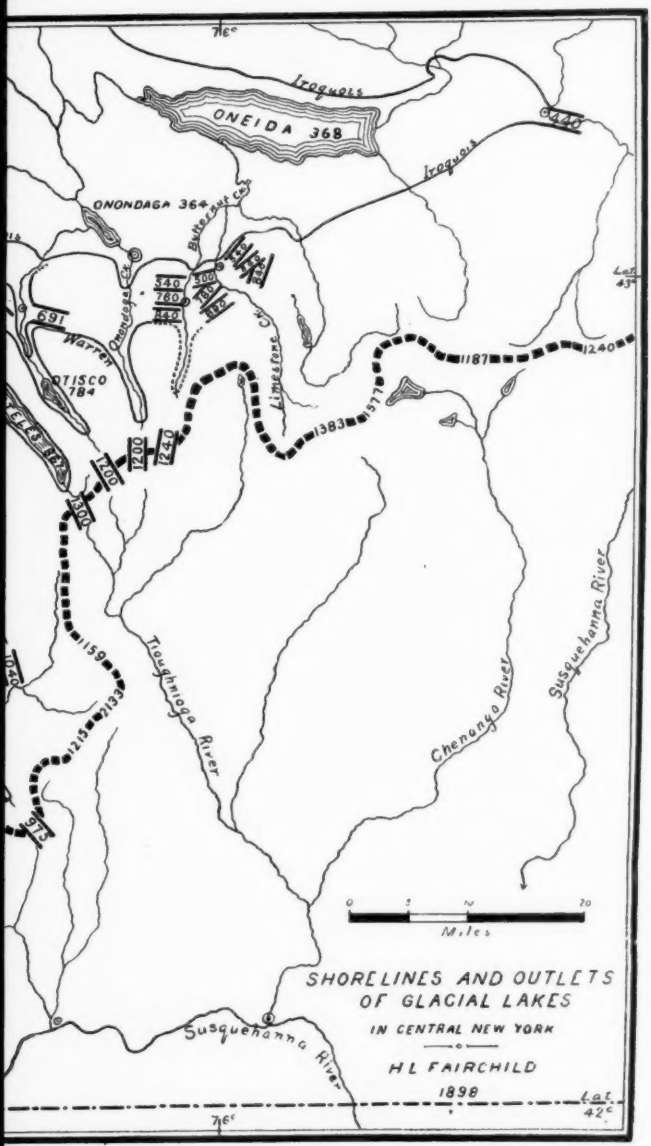

ONTARIO
246
Iroquois
ONEIDA 368
ONONDAGA 364
Mud Creek
Dana
Warren
Flint Ck.
CANANDAIGUA 681
SENECA 618
CAYUGA 378
Newberry
GRASSCOTO
FRANKFORT ESKER 1184
OTISCO 784
Limestone Ck.
Tioughnioga River
Chenango River
Susquehanna River
Chemung River
M. Iles
SHORELINES AND OUTLETS
OF GLACIAL LAKES
IN CENTRAL NEW YORK
H L FAIRCHILD
1898
NEW YORK
PENNSYLVANIA

Plate VI.


Iroquois
ONEIDA 368
Iroquois
ONONDAGA 364
Butternut Cr.
Onondaga Cr.
Warren
691
784
Limestone Cr.
1187
1240
1383
1577
1159
1213
1133
Tioughnioga River
Chenango River
Susquehanna River
0 5 10 20
Miles
SHORELINES AND OUTLETS
OF GLACIAL LAKES
IN CENTRAL NEW YORK
H L FAIRCHILD
1898
Susquehanna River
Lat. 42°

Extinction.—In the study of the glacial lake history, it was recognized that Lake Newberry must have been destroyed by outflow either to the east or west, eastward by the Mohawk Valley, or westward into Lake Warren. It was a matter of the quicker removal of the ice barrier in one or the other of two critical localities. And wherever the escape occurred we should find the scourways across the north-sloping land, or some transverse configuration with traces of erosion by the escaping waters, and with a favoring relation of valleys or openings beyond. With some knowledge of the topography of the critical east and west localities and their general conditions and relations, it was thought more probable that the Newberry waters escaped westward, and an examination of the eastern area at the foot of Skaneateles and Otisco Valleys, supplemented by a study of the Skaneateles sheet (unpublished) of the New York topographic map, confirms this view of the Newberry extinction. The writer has found no evidences of water at the Newberry level in the Skaneateles Valley, but such should occur if the waters found egress eastward, because the low Mandana pass (900 feet), east side of the middle of the valley, would have let in the waters long before the ice dam was removed from the high ground northeast of the valley. Indeed no conclusive evidence has been found of Newberry waters in the Owasco Valley, west of the Skaneateles. Moreover, the channel cut by the eastward escape of the subsequent and lower Warren waters lies only a few miles north of the high ground at the north end of Skaneateles Valley, and within this short distance of critical ground there are no east and west scourways or any evidence of water-flow between the Newberry and the Warren levels.

Lake Newberry was destroyed by draining westward over a point of land about five miles southeast of Canandaigua village, and midway between Ennerdale railroad station and Reed's Corners (see Plate VI). Here are well-defined and capacious channels, at successively lower levels, lying athwart the ice-moulded or drumlin surface. They occur on the south side of a morainal series and truncate the ends of drumlins. Here the Newberry waters were lowered to the Warren level, being drained from about 980 feet elevation down to 880 feet, and at the lower level the waters of the former Newberry area became a part of the great Lake Warren.

Lake Warren.

*General Description.**—This glacial lake was of great area. It is believed to have covered at least the southern part of the Huron basin, all of the Erie basin, and as much of the Ontario

* A fuller description will be found in Bull. Geol. Soc. Amer., vol. viii, p. 269.

basin as was not still buried under the great ice-body. The beaches have been traced in the Huron-Erie basin and along the southern slope of the Erie and Ontario basins into Western New York as far east as the meridian of Rochester. The outlet of the lake was certainly westward into Mississippi drainage, probably across Michigan into the glacial lake Chicago. The name was given by J. W. Spencer.

Invasion of Central New York. — The Warren waters existed in the extreme western part of the state, within the Erie basin, for a long time before they were allowed to enter the central part of the state. When the front of the ice barrier moved back, northward, from the high ground north of Batavia, Lake Warren extended eastward, as a relatively narrow belt of water, along the east and west ice-wall, with southward prolongations in the valleys. The waters occupied the valley of Oatka Creek to beyond Warsaw; of the Genesee and Canaseraga Valleys to beyond Dansville; the valley of Conesus, and ultimately the valleys of Honeoye, Mud Creek (Bristol), Canandaigua, Flint Creek, Seneca, Keuka (through Seneca), Cayuga, Owasco, Skaneateles, Otisco, Onondaga, and possibly Butternut. The valleys of Hemlock and Canadice were above the Warren level.

The breadth and southward extent of Warren waters in the valleys of Keuka, Seneca, and Cayuga were less than that of the Newberry waters, as they were about 100 feet lower. The northern boundary, the ice front, was probably much straighter or less lobate than that of Newberry. The glacial border being further north, on the low northern plain, the effect of the Finger Lakes valleys was nearly or entirely lost upon the ice-front, which was probably an arcuate line not far from the north ends of the present lakes.

Shorelines and Elevations.—The Warren shore has been traced with sufficient continuity to positively identify it as far east as Lima, south of Rochester, where it has an elevation of 879 feet. Well-defined beaches may doubtless be found further east, but the shoreline phenomena already discovered are delta terraces and bars and spits connected with deltas. Like the Newberry phenomena, these have been elsewhere described and need only be mentioned here.

In the Canandaigua Valley the Warren level appears upon the deltas, but the elevations have not been measured. A fragment of beach has been found southeast of Canandaigua village and one mile west of Reeds corners with elevation of about 880 feet. In the Keuka Valley the Warren level is very evident as the lowest of the strong delta terraces. These vary in elevation from 830 to 870 feet. In the Seneca Valley several terrace bars have been measured as follows: At Montour

Falls, 840 feet; between Montour Falls and Odessa, 840 feet; at Himrods, 853 feet (?); at Hector Station, 872 feet; at Lodi Station, 874 feet; at Ovid, 877 feet.

In the Cayuga Valley the Warren levels have been measured at Coy Glen, 831 feet, with a higher bench 865 feet; at Willow Creek, 829 to 863 feet; at Taughannock Falls, 826 to 849 feet; at Trumansburg, 829 to 834 feet. In the Owasco Valley, at Locke, 860 to 870 feet, and at Moravia, 855 to 882 feet (aneroid). The two levels in the Cayuga and Owasco Valleys are significant. These vary from 23 to 34 feet apart and are thought to represent the fall from the normal Warren level down to the first enduring level with eastward discharge, possibly the rock sill at the head of the channel southeast of Jamesville (see pages 251 and 260). The lower level is hypo-Warren, or, more accurately, hyper-Iroquois.

Extinction.—The life of Lake Warren was terminated by the opening of a new and lower outlet, eastward, past the ice-front, to the Mohawk-Hudson. For a long period, perhaps several thousand years, its waters had been tributary to the Mississippi, but for some centuries they had been creeping eastward along the ice front as if in patient search for a new escape that was sure to come. It should be kept in mind that the district we are considering has been uplifted to its present level since that time; it then lay at a much lower altitude.

The most western spillway of the eastern discharge of Warren waters is on the crest of the Corniferous escarpment four miles west-northwest of Marcellus village, and the same distance north-northeast of Skaneateles. The present elevation of the sill or intake at the lowest point is given by Mr. Gilbert as 812 feet, which is perhaps 80 or 90 feet under the theoretical Warren plane. There has been some removal of overlying drift and possibly of shale, and the intake has probably migrated backward to the present point. But this outlet, the "Gulf," was probably not the earliest nor highest spillway. In another writing (see reference, p. 256) reasons have been given for believing that the Warren waters at their full height invaded the region as far east as the Onondaga Valley and possibly the Butternut Valley. Their first and highest eastern escape was east of the Onondaga Valley, in the vicinity of Jamesville (see map, p. 251) and the waters were quietly lowered upon the hollows between drumlins at the head of the Gulf channel.

For years after the eastern escape was opened Lake Warren must have had two outlets and divided its contribution of surplus water between the Atlantic and the Gulf of Mexico; but soon after the Gulf outlet was opened it doubtless carried the entire overflow. Whenever this occurred the lake was no longer Lake Warren.

This large channel, excavated in Hamilton shales by the Warren overflow, leads southeast four miles, opening into the Otisco Valley two miles south of Marcellus village. The local name is the "Gulf," which, for want of a better name is retained. The waters were again impounded in the Otisco Valley, where the debris derived from the excavation of the Gulf was piled in a delta, with terraces from 860 down to 800 feet elevation. The Otisco waters (Marcellus Lake) escaped by another great rock channel, Cedarvale channel (named after a hamlet in the gorge) that heads at Marcellus village and leads southeast to the Onondaga Valley at South Onondaga.

These great channels, with others farther east (see page 251), show the final result of some centuries of erosion. Their initiation was probably not in the present geographic sequence, and the primitive conditions of elevation, etc., are uncertain. The Skaneateles and Tully sheets of the New York State topographic map will, when published, show the Gulf and Cedarvale channels and deltas with clearness.* Dr. Gilbert was the first to study these channels and to point out their relationship to those lying further east.†

Hyper-Iroquois Waters.

Lake Dana ("*Geneva*" *beach*).—At the time of Warren extinction the Ontario basin was still largely occupied by the glacier. Certainly most of the eastern part of the basin north of the locality now under discussion was filled with the ice. Considerable time was required for the front of this ice-body to recede so far as to permit an expanse of Ontario waters in the region under discussion, with immediate outlet at Rome—that is to say, for the westward expansion of Lake Iroquois. During this interval the glacial waters fell about 500 feet, from the Warren plane to the Iroquois. This subsidence was not a steady or continuous lowering, but *per saltum*,—a series of comparatively sudden falls, as progressively lower outlets were opened, with intervals of steady level, or very slow falling, as each outlet remained effective.

During one of these phases of repose it is believed that the beach was formed which has been traced along the west side of the Seneca Valley and described in a former paper as the "Geneva" beach.‡ It is also believed that the level of the beach correlates with the Cedarvale outlet at Marcellus. This is the only waterlevel between the Warren and Iroquois planes

* To the U. S. Geological Survey the writer is indebted for advance copies of the maps in manuscript which have facilitated this study.

† Old Tracks of Erian Drainage in Western New York, by G. K. Gilbert. Bull. Geol. Soc. Amer., vol. viii, p. 285.

‡ Bull. Geol. Soc. Amer., vol. viii, p. 281; vol. x, p. 44.

that has left any strong shoreline phenomena, so far as at present observed. Theoretically its evidences should be found from Marcellus westward throughout the Ontario and Erie basins, and it may be the subject of much future study. A distinctive name is required, and it is proposed to call the water Lake Dana, after Professor James D. Dana, the early leader in American glacial geology.

Since the publication of the former description the beach has been traced south from Geneva to near Dresden, and shoreline phenomena have been observed in the Cayuga Valley at a theoretically corresponding level. The elevations in the Seneca Valley are as follows: near Angus station, Fall Brook railroad, 671 feet; near Earle's station, 679 feet; west of Geneva, 700 feet; south of Phelps, 713 feet. The deformation of the beach is about three feet per mile, on north and south line, and it lies 180± feet under the Warren plane. Evidences of this lake should be found throughout the valleys of Cayuga and Seneca and westward at 170 to 190 feet under the Warren level. This water could not occupy the valleys of Keuka, Owasco, Skaneateles, nor Otisco, as these lie above its plane.

The magnificent Cedarvale channel, with its huge delta, has been described in another writing (see reference, p. 256). It heads on Corniferous limestone and shale, one-fourth mile southeast of Marcellus village, with an average elevation of 691 feet, which elevation correlates well with the beach altitude of the same parallel, something over 700 feet, making allowance for depth of water over the sill and the later down-cutting, with some east and west deformation of the land.

The change from the Warren level to the Dana level did not come by the slow down-cutting of the head of the Gulf channel, but by the recession of the ice front so that the glacial waters abandoned that outlet and found free access to the Marcellus valley from the north.

The eastern limit of Lake Dana was practically the same as that of Lake Warren, but with a surface 180± feet lower. Its southern margin must have been more contracted, while the ice boundary upon the north was somewhat further removed. Its western limits have not been determined, but phenomena attributed to this water have been observed as far west as the Genesee River. Without some unexpected barrier, like great land elevation or far readvance of the ice sheet, there seems no escape from the conclusion that Lake Dana must have covered the Erie basin. Being weak as compared with the Warren phenomena, these have been overlooked, but it is predicted that they will be found westward over a wide area. The hypothetical shoreline is indicated on the map.

Water levels between Lakes Dana and Iroquois.—In the district south and east of Syracuse there are several other abandoned channels. All are lower than those described above; some of them are in rock and of great capacity. The most interesting ones are the sluiceways which carried eastward the overflow of Warren and Dana Lakes, and which constitute, with the Gulf and Cedarvale channels, a connected series (see page 251). All this series lie transverse to the present drainage and conveyed eastward, across the intervening high lands, the waters impounded by the ice-dam in the north and south valleys. The flood poured into the Onondaga Valley from the hypo-Warren and Dana Lakes by the Cedarvale channel was carried over to the Butternut Valley by three successive channels lying southeast of Syracuse and near Jamesville. The lowest and most important is a great "rock cut," three miles southeast of Syracuse. While perhaps not the largest, this channel is the finest, the most typical, and the most easily seen of any glacial channel in New York. It is about three miles long and is traversed, its whole length, by the Delaware, Lackawanna & Western railroad, and has been named the "Railroad" channel. The walls are nearly vertical bare rock, 125 to 150 feet high, and the bottom of the cut will average 900 feet wide.

The water was conveyed eastward from the Butternut Valley to the Limestone Valley by other great rock channels, the largest and latest one heading opposite the mouth of the Railroad channel and extending somewhat over three miles to High Bridge, south of Fayetteville. The Syracuse sheet of the topographic map well portrays the Railroad channel, but the High Bridge channel is not well delineated on the north side by the 20-feet contours. From the valley of Limestone Creek three channels lead northeast; the highest of these heads in a cataract, one and one-half miles southwest of Mycenae, and joins the second channel, which ends at Mycenae above the Iroquois level. The lower waterway holds Round and Green Lakes, which occupy depressions produced, as pointed out by Dr. Gilbert, by the sinking of strata due to solution of the underlying salt beds. The heads of these three channels are higher than the High Bridge channel, and they probably ceased to be effective earlier. Indeed they were probably the first of the east and west series to be abandoned, excepting the 890 feet ("Green's") channel, south of High Bridge.

Northward of the outlet series described above, lies another, later, series of channels. The Syracuse sheet exhibits a broad channel, heading a mile east of Fairmount at 500 feet elevation, which passes eastward directly through the center of Syracuse, where its elevation is only 400 feet. West of Syra-

cuse they have not been mapped, but another and lower water-course may be seen from the Auburn branch of the New York Central railroad, heading in a cataract west of Marcellus station and followed by the railroad eastward to beyond Camillus.

It is possible that one or more of the channels lower in elevation than the Cedarvale channel may have established for a short time an independent lake level, but such waters could not have extended westward beyond the Ontario basin, as the planes of these outlets are below that of Niagara.

Upon the north sides of these channels the morainal drift is heavy and the topography more irregular than shown by the topographic sheets.

Lake Iroquois.

These latest glacial waters of the Ontario basin have been so long known that extended description is unnecessary here. The name was given by J. W. Spencer, and Mr. Gilbert correlated the shorelines with the col and ancient outlet at Rome. This large and important body of water had a long life, during which it matured its western shorelines and expanded to an area larger than that of the present Ontario, as its surface was far higher than Ontario, although the retreating ice barrier during most of the life of Iroquois held possession of some of the northern or northeastern part of the basin.

During the life of Iroquois the differential elevation toward the north-northwest, or canting of the basin toward the south-southwest, produced a shifting of the shorelines, a transgression of the waters upon the southern shores and a recession from the northern shores. This has been graphically shown by Dr. Gilbert.*

The Iroquois shoreline was not matured east of Sodus although abundant evidence of the water-action exists. South and east of Sodus Bay the map gives only the general or hypothetical position of the water line.

The lake became extinct by the opening of the St. Lawrence Valley and lowering of the water below the Rome outlet. At this time the altitude of the basin was such that the head of the St. Lawrence channel, at the Thousand Islands, was below sea-level, and a gulf of the ocean occupied the Ontario basin. The differential uplift, however, soon barred the sea and initiated the present lake and river.

* "The History of the Niagara River," 6th Ann. Rept. Com. of State Res. of Niagara, Albany, 1890.

ART. XXVI.—*A Rapid Method for the Determination of the Amount of Soluble Mineral Matter in a Soil;* by THOS. H. MEANS.

A RAPID and simple method for the determination of the per cent of soluble matter which a soil contains has been found very desirable where areas of soil are to be studied in any detail. Particularly is this true in the arid and semi-arid regions of the West where accumulations of soluble salts have been the cause of injury to valuable tracts of land. The ordinary methods of chemical analysis are entirely too laborious for the examination of a large number of samples, and, besides, chemical analyses cannot be made out in the field. In field studies it is of great advantage to know the salt-content of the soil at hand. The accumulation of "alkali," wherever irrigation has been practiced a few years, has pointed out the great necessity of studying the conditions of the soluble matter before water is applied. Enormous sums of money are being invested in irrigation, and a great deal of this expended capital has been, or will be, lost unless new systems of irrigation and drainage are devised. There can be no question that the study of the soil, the alkali and the methods for the prevention of its accumulation, must form an integral part of every irrigation engineering problem. Not only must the surface of the soil be examined, but the per cent of salt found in the subsoil to a depth of 30 or 40 feet should be known. In order that underground maps of the salt may be prepared with much greater ease than is possible with ordinary means, the following method is suggested.

The electrical conductivity of water varies with the amount of dissociated salt that is present. The method is practically a means of determining the specific electrical conductivity (or resistance) of the solution between the soil grains. When this is known, the amount of any salt which will produce this same conductivity may be calculated from published tables of the conductivity of salt solutions.*

In order to determine the effect of the solid grains of the soil upon the resistance of the solution, the following experiment was arranged. A hard rubber cell with parallel sides of metal was partly filled with a solution of known specific resistance. Then as much dry soil was added as would be taken up by the solution, forming a saturated soil. The resistance was in all cases increased. A correction was made for the soluble matter contained in the soil, and the increase in

* Kohlrausch, Wied. Ann., 1879, vol. vi, p. 145.

resistance, due to the addition of the solid non-conducting particles, was therefore determined. In this way a large number of samples were examined and it was found that the increase in resistance was nearly the same for soils of very different textures. The following table contains the most important of the results:

Number of determinations.	Soil and character.	Per cent water when saturated.*	Initial resistance. Ohms.	Resistance after soil is added. Ohms.	Factor of texture.
10	Loess, Virginia City, Ill. Silty	31·84	1	1·81	·551
10	" " " "	35·36	1	1·73	·579
10	Limestone soil, Blacksburg, Va. Heavy clay	69·41	1	1·90	·527
10	" " " " "	72·49	1	1·85	·542
5	Red Land, S. C. Clay soil	40·00	1	1·83	·557
5	" " "	36·35	1	1·88	·533
5	" " "	32·75	1	1·93	·517
10	Sea Island, Cotton soil, S. C. Fine sand	25·77	1	1·83	·547
10	Early Truck soil, Md. Coarse sand	17·94	1	1·78	·563
				Average	·548

These soils, as seen in the table, vary from the light sandy lands, which require less than 18 per cent (of their dry weight) of water to saturate them, to the heaviest of clays, requiring 70 per cent of water for saturation. Determinations were made with two or three amounts of water in some of the soils in order to strike as near as possible the point of saturation. The last column is the ratio between the resistance after the soil was saturated and the initial resistance of the solution. If the resistance (between parallel electrodes) of a saturated soil is multiplied by this figure (the factor of texture), the resistance of the solution between the soil grains will be found.

The salt determination is performed in practice as follows:

1. Saturate the soil with distilled water. The point of saturation can very easily be found and, with a little practice, duplicate samples can be mixed to within a small error.

2. Pack saturated soil in a cubic cell with two sides of metal and take the resistance. Read the temperature, and correct resistance for temperature.† Multiply the corrected resistance by the factor of texture, 0·55. This gives the resistance of the soil solution alone in the cubic cell.

3. From the known weight of soil in the cell and the percentage of water required to saturate the soil, find the number of cubic centimeters of soil moisture between the soil grains. In field work it is sufficiently accurate to take the average of

* Calculated on dry weight of soil.

† Bulletin 7, Division of Soils, Department of Agriculture. Bulletin 8, Division of Soils, Department of Agriculture, page 27.

several laboratory determinations of this quantity. The amount of soil moisture being known, the cell factor (the figure by which the resistance must be multiplied to obtain specific resistance) for this quantity can be found.*

4. Multiply the resistance found in (2) by the cell factor and obtain the specific resistance of the soil solution. For dilute solutions the per cent of salt present is nearly inversely proportional to the resistance. In a study of the alkali soils of the West† where the salts are of rather uniform chemical composition, it is of great advantage to have a more accurate method of calculating the results. In such studies, a solution of the average composition of the salts is made up and its resistance-salt curve determined. In this way the per cent of salt by weight can be reckoned for any resistance. Such a proceeding was followed in some studies of alkali soils in Montana.‡

This method offers special advantage in the study of alkali soils. The apparatus necessary can readily be carried in the field. A convenient form of Wheatstone's bridge adapted to field use has been designed by Mr. Lyman J. Briggs of this laboratory.

The auger for sampling the soil is in general use in the study of surface geology.§ The only other apparatus necessary are the cubic cell,‖ thermometer, mixing dish and bottle of distilled water.

This method offers a ready means for the detailed study of irrigated districts. Two men can examine from sixty to one hundred samples of soil in a day and in this way cover considerable ground, obtaining sufficient data for the construction of salt maps of the district.

U. S. Department of Agriculture, Division of Soils.

* Ostwald's Physico-Chemical Measurements, translated by Walker, page 225. Note.—If a cubical cell is used—such a cell 4^{cm} internal dimensions has given me the best results—the cell factor will vary inversely as the number of cubic centimeters of solution present.

† Whitney and Means, Bulletin 14, Division of Soils, Department of Agriculture.

‡ Loc. cit.

§ Darton, Am. Geol., vol. vii, page 117–119.

‖ Whitney and Means, Bulletin 8, Division of Soils, Department of Agriculture, page 11.

ART. XXVII.—*On a New Type of Telescope Objective especially adapted for Spectroscopic Use;* by CHARLES S. HASTINGS.

THE ordinary achromatic doublet as invented by Dolland in the last century, is, as is well known, very far from complying with the condition implied in its name. For telescopes of small aperture, or even for those of very considerable aperture, if a ratio of focal length to aperture as great as that customary with Dolland be employed, the defect in color correction is neither very conspicuous nor very harmful in ordinary use. But if the apertures are very large, as in our modern astronomical instruments, or if the length be reduced relatively to the diameter of the objective, this defect of secondary color aberration becomes very conspicuous and reduces the optical efficiency of the instrument very materially. The maximum inconvenience of the defect, however, falls upon the spectroscopist, who finds that, although the optical efficiency of his instrument is independent of the wave-length of light which he happens to be observing, the instrumental adjustments must undergo frequent changes for adaptation to different portions of the spectrum. Another familiar and obvious consequence of the secondary color defect is the impracticability of adapting the same instrument to purposes of both eye and photographic observation.

It follows, therefore, that the solution of the problem, apparently first seriously undertaken by Fraunhofer, namely, to devise an absolutely color-free objective, is, and has long been, of continuously increasing moment. Fraunhofer failed; but unless I greatly misapprehend the meaning of his own record of his work, the effort led directly to the discovery of the Fraunhofer lines and to the beginning of spectroscopy. It is true that nowhere, as far as appears in his published writings, does he state that this was his aim; but in view of his very extended experiments in varying the constitution of his glasses, of his studies of the minute dispersion characteristics of various substances, and of the extraordinary skill and conscientiousness in perfecting an instrument which has possessed no other error of importance since his unequaled contributions to the art of telescope-making, few will question the validity of the inference.

Doubtless many investigators since Fraunhofer's time have attacked the same problem, but, so far as I am aware, without any recorded success until the writer showed, in a paper published in this Journal, vol. xviii, p. 429, that there were certain glasses, unfortunately not then procurable, which would yield

in a triple combination an objective entirely free from color. Since then the extraordinary increase in number of materials at the command of the optician, resulting from the labors of Dr. Schott of Jena, led the writer to return to the problem with the results which were published in a paper in vol. xxxvii of the same Journal, in 1889. A general method of dealing with all such problems was there developed and a number of triads were indicated which would yield the most favorable results. It is true that those given included a phosphate glass which was believed by the makers to be permanent and has since proved not to be so; but it was distinctly stated that the table exhibited a considerable number of other promising combinations, and the general method of recognizing them was pointed out.

It may properly be stated here that the latter paper also contained a general discussion of interesting double combinations, one of which promised to be of great value to spectroscopists; but the inability of glass makers to supply large disks of the materials in question proved an unforeseen difficulty. Still, the writer employed this construction for a number of years for his spectrometer and only displaced it recently by an improved type of objective. Professor Keeler has also employed the same construction, made by Mr. Brashear with my aid, satisfactorily in spectroscope work.

The experiments with triple combinations which followed the paper last named met with an unforeseen difficulty. The particular triad which promised most in theory proved to have in one of its members a perishable glass. This might possibly have been used by covering the objectionable material by a more permanent glass cemented to it, but this course is not without risk, and certain defects, to be noted later, are not so readily eliminated if this method be chosen. The only practicable course seemed to lie in replacing this material by one beyond suspicion, and much time was spent in investigating the possibilities of this means. It was found, as appears from the paper cited above, that there was no difficulty in selecting triads which would meet the analytical condition, insuring complete elimination of color and subject to practical limitations as regards permanency; but the necessarily greater curvatures of the lens surfaces introduced a new source of imperfection, namely, chromatic difference of spherical aberration. Of course, this, like all other errors, is present to a greater or less degree in all optical instruments which depend in any way upon refraction for their action. In telescopes, however, this error has never been sufficiently great to betray itself to the users, although clearly indicated by theory. Gauss, indeed, a long time ago showed how to reduce this particular error to a

residual of a higher order of minuteness, but the fact that his construction has never come into use is a most convincing proof that the error is quite negligible as compared to other defects inherent in the ordinary construction. But when we try to make a color-free triple objective after the methods of the paper of 1889, we find that the defect in question becomes of great moment. Especially is this true if we prescribe the cementing of the objective so that there shall be only two free surfaces. Such an objective, if corrected as regards spherical aberration for light-waves of mean length, would have strong positive spherical aberration for the red and negative for the violet ends of the spectrum. It is true that this defect might not prove very obvious for a telescope which is to be used only for objects which are approximately white, but it would be intolerable in spectroscopic use. The obvious method of reducing the error is to increase the ratio of the focal length to the aperture. This method, however, would introduce such serious structural and mechanical difficulties, and so far reduce the convenience of handling all spectroscopes to which it might be applied, that it seemed to me quite impracticable.

As a possible means of securing the end in view, convinced as I am that its importance warrants any amount of labor, I lately turned to a consideration of the possibilities possessed by a combination of four varieties of glass. The investigation is necessarily somewhat laborious as appears from the unusual conditions imposed from the outset; but the time expended in attaining complete success was short compared to the protracted investigations which led to a definitive rejection of the triplet as quite inadequate. In short, I have constructed an objective, consisting of a quadruple combination of silicate flint, borosilicate flint, silicate crown and barium crown, which possesses all the properties demanded. It has but two free surfaces, the four lenses being cemented together. With an aperture of one-tenth the focal length, its focal plane is rigidly the same for all wave-lengths, from that of the Fraunhofer line A to that of K, while it is sensibly free from chromatic differences of magnification and of spherical aberration. With its perfect color correction, the well-known (but ordinarily overlooked) chromatic aberration of the eye becomes very sensible. This, however, I have eliminated by means of a specially devised ocular, so that in my instrument there is no reason why its length may not be made permanently invariable. One notable advantage in the construction will appear at once to all spectroscopists: wave-surfaces from the collimator being rigidly plane for all wave-lengths, the adjustment of the prisms for minimum deviation—provided always that their faces are accurately plane—ceases to be of importance. Thus a con-

struction, which must have occurred to every one who has seriously studied the theory of the spectroscope, in which the last prism of a train is of half the angle of the remainder and silvered on the back, so that the light retraces its course through the train, becomes entirely practical. Indeed, my experiments with the new telescope lead me to prefer a construction of spectroscope in which the collimator and telescope are set at constant angle, and the prisms, arranged as above, are alone movable. This is the familiar construction of the grating spectroscope.

Although the objective described above consists of four lenses, I imagine that a cemented system of five lenses would in some cases be preferable, especially in relatively large apertures; but there is no doubt in my mind that four kinds of glass are sufficient and, unless greater structural complexity is admitted, necessary for the ends defined.

Should the construction meet my confident expectation and supply the spectroscopist with an optical instrument combining the merits of a reflector with the greater merits of a refractor, it will be convenient to give it a characteristic name suggested by its properties. These are, as given above, chromatic differences of focal distance, of focal length, and of spherical aberration, all reduced to practically zero, together with a minimum possible number of free surfaces. As such an objective is the same in its action upon light of all wave-lengths, I propose to call it an *isokumatic* system.

Mr. Brashear of Allegheny, who made for me the prisms for the study of these glasses, as well as scores of others, and who has shown unfailing good nature and constant readiness to lend me his efficient aid in all my optical investigations, merits my unstinted acknowledgments. I have promised the necessary calculations if he is called upon to carry out for others this difficult piece of optical work which has yielded so much satisfaction to the writer.

Yale University, March, 1899.

Art. XXVIII.—*On the Phenocrysts of Intrusive Igneous Rocks;** by L. V. Pirsson.

The igneous rocks, excluding those which have solidified as uncrystallized glasses, may be roughly divided into two classes, the *granular*, composed of mineral particles of approximately similar size, and the *porphyritic*, consisting of minerals exhibiting a more or less perfect outward crystal form which lie embedded in a so-called groundmass made up of much smaller, usually anhedral,† particles or even wholly or in part of glass. A rock belonging to this latter class is a *porphyry* and the larger embedded crystals are called "porphyritic crystals" or more conveniently "*phenocrysts*," a term proposed by Iddings which has obtained general recognition among geologists.

It is with respect to the origin of these phenocrysts in a certain class of igneous rocks that it is proposed to treat in this article.

Without going into details, it will be sufficient to recall that many petrographers have expressed the view that the phenocrysts of porphyritic rocks, by the very fact of their size, frequent perfection of crystal form and contrast of character to that of the groundmass in which they lie embedded, are older than this groundmass, have been formed under different physical and therefore different geological conditions, in short, not in the place where they now are, but at great depths, and hence they are frequently spoken of as "intratelluric" in origin.‡

The writer has been unable to find in the literature, that any sharp distinction has been drawn between the origin and character of the phenocrysts of *intrusive* igneous rocks and those of the *extrusive* ones or lava flows. This has probably arisen from the belief that phenocrysts are always formed, as stated above, at much greater depths than the place in which they are now found, and that therefore their origin is similar in both cases. It would thus make no difference in regard to their origin and character, whether the ascending magma which contained them was thrust in intrusive masses into the upper portion of the earth's crust or poured out on the surface in flows of lava.

In the present article, however, it is to be carefully noted that the writer confines himself to the phenocrysts of the *intrusive* rocks, as it is intended to show that not all phenocrysts are intratelluric in the sense that they have been formed at much greater depths than they now occur in, but that on the

* Read before the Geological Society of America, December, 1898.

† i. e., having crystal structure but not crystal form.

‡ Rosenbusch, Mass. Gest., 3d ed., 1896, p. 553; Michel-Lévy, Struct. et Class. des Roches, 1889, p. 1 et seq. See also discussion by Zirkel, who does not follow this view, Lehrb. der Petrogr., 2d ed., 1893, vol. i, p. 737 et seq.

contrary in many cases they have been formed in place, and are of contemporaneous origin with the other constituents of the rocks, and the nature of the proofs is partly such that they can be applied only to intrusive rocks, and partly they have not been observed in lavas.

The idea that phenocrysts are not necessarily intratelluric has been expressed by previous writers, and Zirkel* indeed gives a very full discussion of the subject, while Cross† also mentions this belief in alluding to orthoclase phenocrysts which are found in certain laccoliths but not in the peripheral portions. But the subject does not appear to have received in general the attention that its importance merits, and the writer is therefore led to present his own observations bearing on this point, and the deductions he has drawn from them as a contribution to the subject. They have been gathered during the progress of the geological work in Montana, by Mr. W. H. Weed and the writer, and the details have mainly appeared in our publications on that region, but they are now gathered together and generalized for use upon this question. Similar proofs of course occur elsewhere, and they are indeed of general application.

Meaning of intratelluric.—The term "intratelluric" needs a moment's attention. It is probable that different writers have used it with somewhat different ideas, differing as to degree, not as to kind. Nowhere has the writer been able to find a precise definition by an author of what his idea of intratelluric is, but it is certain from the context, that in all cases, as regards *time* and *niveau*, it means an earlier period and greater depth of the magma than that in which it came to rest. Thus in a laccolith formed under a great thickness of sediments, the phenocrysts would be spoken of as the constituents formed in the intratelluric period, that is a lower, earlier period of the magma and in contrast to the groundmass, which is never spoken of in these cases as intratelluric.

Whatever exact ideas writers may have had regarding this term, it may be taken as well assumed that it means a deeper and therefore earlier stage of the magma in the earth's crust, than any in which the intrusive porphyritic rocks have been formed.

Two classes of phenocrysts.—Phenocrysts may be divided into two general classes. First, those which are found only as distinct porphyritic crystals and do not occur as a mineral component of the groundmass, like the micas and hornblendes of many acid rocks, and the olivines of many basic ones; and second, those minerals which are formed both as phenocrysts and also in the groundmass, like the quartz and feldspar of

* Lehrbuch der Petrographie, vol. i, p. 737 et seq., 1893.

† Laccolitic Mountain Groups, U. S. Geol. Surv., 14th Ann. Rep., 1895, p. 231.

acid rocks and the pyroxenes of basic ones. The second class may be termed *recurrent* phenocrysts, meaning that the mineral composing them occurs both as a phenocryst and in the groundmass; Rosenbusch suggests the term in speaking of the recurrence of mineral formation. The other, or first class will be called here monogenetic phenocrysts. This distinction is of importance, as it is chiefly with the recurrent phenocrysts that we shall have to deal.

The proofs that all phenocrysts of intrusive igneous rocks are not intratelluric, but have in many cases been formed in place, and contemporaneously with other constituents may be divided into two classes, those which are megascopic, that is to say, geological or may be observed in the field, and those which are microscopic, or to be gathered by a study of thin sections. The geological proofs will be considered first.

Evidence of contact zones.—In the case of many laccoliths, dikes, sheets and other intrusive masses of igneous rocks of the more acid feldspathic kinds, it has been observed that while the main rock masses are highly porphyritic, often containing phenocrysts of great size, they pass into peripheral zones, which may attain considerable width, in which such phenocrysts are entirely wanting. The border zone is often observed to be dense, aphanitic and totally without phenocrysts either great or small—the constituents are all of one period of formation and allotriomorphic in structure.*

But if the magma contained phenocrysts before coming to rest, they should occur in the border zone as well as elsewhere. It will not do to suggest two separate intrusions in these cases, for the geological "*mise en place*," and the whole character of the occurrences, utterly forbids such a supposition. Nor will it do to say that they previously existed in the border zone, but were redissolved. For the border zone being the part cooled first and most quickly, if they previously existed in it, then there is especially the place where they should occur. If any re-solution should take place, it would be in the center, not at the sides. Nor will it do to partially compromise the matter by saying that in the original magma they were very small and grew greatly after the magma came to rest.

No doubt this often does happen, but in many cases, as stated above, there are *none* in the contact zone, nothing to represent the thickly swarming masses of them in the central portion. In these cases the writer sees no escape from the conclusion, that the phenocrysts were formed in place. The evidence is most common and striking in regard to phenocrysts of the recurrent type, but it has been also observed in those of the monogenetic type.

* Zirkel mentions similar instances, loc. cit., p. 740.

Evidence of dikes and sheets.—In many cases we have clear and indisputable evidence, that systems of dikes and sheets have been formed by a single geological act; that is, filled from a single parent magma, at the same time and under the same conditions, and they have of course the same chemical composition. An example occurring in the Judith Mts.* of Montana has been recently described by the writer. The attendant fringing sheets lying above many laccoliths may also be cited as examples. Yet in many of these cases some sheets or dikes may have large and well-developed phenocrysts, others none at all. The laccolith may be full of phenocrysts; its attendant sheets or some of them may be entirely devoid of them. A sheet of tinguaite in the Judith Mts. contains phenocrysts of feldspar as large as one's hand, but a narrow sheet of the same rock which the general geologic history of the district shows was intruded at the same time, and which has a similar composition, has only very minute ones arranged in flow structure. In these cases, had they previously existed in the parent magma, they should be found in both alike. The conclusion in these cases is that the phenocrysts have formed in the places where they now are.

Evidence of fluidal phenomena.—In the case of some dikes and sheets it has been noticed that the phenocrysts of feldspar, which have a flat tabular form, have a definite arrangement throughout the mass, with the flat sides parallel to the bounding walls, or in other words, as it is commonly called, a "fluidal" or "flow structure." Sometimes they are rather irregularly distributed, collected in groups or in lines, and are just as apt to occur close to the border zone, at the bounding wall, as elsewhere in the dike. Such instances show clearly the effects of tabular plates being moved along in a liquid, and they prove that the phenocrysts were formed in the magma before it came to rest. How long before we are of course unable to determine, but in these cases they may be "intratelluric," so far as any definite meaning can be attached to this term.

In other dikes and sheets, the phenocrysts have no oriented arrangement in the mass, their orientation is wholly haphazard, they occur evenly distributed throughout, or they may be very small or of different character, or even wholly wanting in the border zones, and this in spite of the fact that they may have a pronounced tabular development.

If in the former cases mentioned the evidence proves that the phenocrysts were formed prior to injection, then the absence of such evidence, that is to say its converse, proves just as clearly that these flat phenocrysts were formed after injection when the magma had come to rest or in other words in place.

* 18th Ann. Rep. U. S. Geol. Surv., pp. 551 and 572, 1898.

Moreover these flat phenocrysts, whether oriented or not, are of great value in throwing light on another question in theoretic petrology—whether phenocrysts ever move in the magma after it has come to rest; that is, whether they sink down in obedience to gravity. In the cases mentioned it is clear that they have not moved or they would have arranged themselves in obedience to the laws governing the movement downward of flat plates through fluids; they would be disposed with their flat sides downward or perpendicular to the walls of the dike. The writer has never seen such an occurrence nor been able to find any description of one, and until such a case has been found the evidence is against the idea that phenocrysts sink through gravity and evidently because the magma is too viscous. They could not assume such a position in an upward moving magma because the motion must be differential and would arrange them in the opposite direction; hence this orientation would show that they had moved and not the magma. The thicker accumulation of phenocrysts at the bottom of an intruded sheet, which has sometimes been noticed, would not prove they had fallen through gravity unless they had this arrangement, since that may merely show that the physical conditions necessary for the production of phenocrysts were more favorable and operative there than in the upper portion.

To return again to the formation of phenocrysts in place,—from the evidences given above, when we find that in dikes and sheets flat tabular phenocrysts such as the feldspars of many acid rocks or the large mica tables of certain basic ones are scattered without orientation, we may conclude that they have been formed in place and are not "intratelluric."

Evidence of porphyritic granites.—It is well known that many granites contain large porphyritic feldspars, often of great size. The granites may have so coarse a grain that in the absence of these feldspars no one would think of them as other than typical granular rocks. The same is also true at times of other rocks besides granites. The evidence that these afford is chiefly of a negative kind, but it is useful to consider in this connection. It is evidence not so much of the *time* and *place* of the formation of phenocrysts as of the *cause* and *manner* of formation. To treat these questions fully would lead us into the discussion of the "*mise en place*" and the structure and classification of igneous rocks, which would be beyond the limits of this article. It will therefore be sufficient to ask one or two questions. Are these large phenocrysts of granites to be considered intratelluric or not, or is granite itself and all its constituents to be regarded as intratelluric? The difference between the porphyritic and the granular structures has been regarded by some, so far as their origin is con-

cerned, as a difference not alone of *degree* but of *kind*. If so, what is this precise difference and why should granular rocks ever possess a porphyritic structure?

What the significance of these crystals really is according to the author's belief will be shown later on.

Microscopical evidence.—We now come to those proofs which are to be seen in the minute internal structures of the phenocrysts when seen in thin section under the microscope. They may be divided into two classes, *external*, or to be seen in the minerals surrounding the phenocryst, and *internal*, to be seen in the minerals which the phenocryst encloses. We will consider the latter first.

Internal evidence.—While the majority of phenocrysts are homogeneous and free from inclusions, in a large number of cases they are not, but contain the other rock minerals. These are usually those of an older period of formation, such as apatites and ores, and their explanation appears simple, but in some instances the phenocrysts may enclose *all* the other rock minerals including crystals of the same mineral as they themselves are composed of. Thus large orthoclases are seen enclosing other orthoclases and quartz. If the enclosed mineral has the same composition and a similar orientation as the phenocryst, it becomes of course an integral portion of the crystal and the enclosure cannot be detected, but it often does not and is then readily identified. In these cases it is impossible to avoid the conclusion that not only was the phenocryst formed in place but contemporaneously with the other minerals. At such times the included minerals are scattered throughout the whole extent of the phenocrysts, but often they are found only in outer zones, indicating that the inner portion had formed first and that later the phenocryst was growing and expanding while the groundmass was crystallizing and was thus including it.* The ability of crystallizing material to orient itself over considerable areas and enclose the other constituents is well illustrated in the poikilitic structure as seen in the quartzes of rhyolites, the orthoclases of shonkinites and the hornblendes and micas of the very basic rocks.

External evidence.—But growing and expanding phenocrysts do not always enclose the other minerals of the groundmass with which they come in contact. On the contrary, like all crystallizing substances, they endeavor to exclude impurities and more commonly they reject and push them along as they grow. Usually the minerals which make up the groundmasses of porphyritic rocks have an isodiametric development, they have therefore no orientation as regards form, and it is hence difficult to tell whether such particles lying alongside pheno-

* These Montana instances give additional force to those mentioned by Zirkel in his discussion of the subject, loc. cit., p. 747.

crysts have been rejected and pushed or not. In certain cases the microlites of the groundmass have however an unequal development—they may be thin flat plates like the feldspars of some trachytes and andesites or slender rods like the ægirites of some phonolitic rocks. In such cases it is common to observe that the microlites have a length orientation parallel to *each* face of the large crystal forming the phenocryst, and not only this but the larger the phenocryst is, the more evident this becomes; they have been more crowded and the arrangement is more evident. This applies of course only to those microlites in the immediate neighborhood of the phenocryst. In the case of the large feldspar phenocrysts of some Montana tinguaites the crystals are covered with a perfect felt of similarly oriented ægirite needles.* The arrangement is precisely what would happen if a scattered group of matches lying on a table should be swept to one side by a book and was caused without doubt by a quite similar process.

Such arrangements have been largely either overlooked or probably confounded with fluidal or flow structures. The latter, caused by movements or currents in the crystallizing magma, is however easily told, since in that case all of the constituents of the period are alike affected, both phenocrysts and microlites being drawn out into waving lines or streams, while in case the orientation is produced by the expansion of the phenocrysts the microlites are arranged parallel to each of its crystallographic faces, have no orientation in the interspaces and the phenocrysts themselves have also no orientation. This *expansion structure*—to coin a term for it—around phenocrysts may of course occur in combination with fluidal structure and merge into it, but typical cases of it are easily told and should be more generally noted in petrographic descriptions.

This evidence then goes to help the general proposition that some phenocrysts are formed in the places where they now are, for they were expanding and growing vigorously while the groundmass was crystallizing and a magma whose groundmass is crystallizing has already reached the place it is destined to occupy.

Summation of evidence.—The value of evidence is cumulative and increases, not in an arithmetical, but in a geometrical ratio. A single fact may indicate definitely a certain hypothesis as its explanation, but it may also be an exception to a general rule. When we can bring a second fact to support it, the probability of the correctness of the hypothesis is greatly increased, and when a considerable number of such facts are found, all pointing to the same explanation, we may reasonably consider it as proved. Thus, when we find that a dike contains flat tabular phenocrysts, which show no orientation, and are wanting in the border zone of contact and contain all the other

* This Journal, IV, ii, 1896, p. 191.

rock constituents, and when this dike is one of a set filled by the same injection which may or may not have similar phenocrysts, we are thoroughly justified in assuming that its phenocrysts are formed in place and are not intratelluric.

Evidences of intratelluric origin.—We should now consider the evidences on which is based the view that phenocrysts have been formed at great depths under wholly different conditions from the other rock constituents. So far as the writer can discover, they are these,—the contrast in size and crystal form of phenocryst to the constituents of the groundmass, the fluidal arrangement the phenocrysts sometimes possess and the fact that they are often corroded or changed in character, that is resolved.

But the contrast of form and size, as we shall presently show, may be explained in quite a different way; the fluidal arrangement certainly shows that the phenocrysts were formed before the magma came to rest, but it does not show how long before or that it may not have been just previously; while the corroded and altered crystals show a change of *conditions*, not necessarily a change of *place*, and although this may be a logical inference it is still not the only one.

From the facts at our command, therefore, it appears most reasonable to say that in some cases we know that phenocrysts have been formed in place; in other cases we know that they were formed prior to injection, but how long and how far we do not know, and that in the great majority of cases we do not know whether they were formed in place or not. It is the author's belief that the majority are formed in place for reasons which it is now proper to give.

Conditions governing the formation of rock structure.—So far as the writer can understand, the French believe in two distinct and different periods of consolidation for all intrusive rocks both granular and porphyritic; many if not most of the Germans believe in one for the granular and two for the porphyritic; like some petrographers, the writer sees no *necessity* for more than one in both.

The conditions governing the consolidation and crystallization of an igneous magma are complex, and many of them, perhaps all, are as yet ill understood. The fall of temperature is the most important, but the chemical composition of the magma, the influence of mineralizing vapors and the pressure are also of great importance. Another important consideration which has been greatly overlooked is increasing viscosity, which depends on chemical composition and temperature. It would be impossible to discuss all these in full, and the writer therefore confines himself to a brief statement of his own views.

The greatest determinant in the formation of rock structure is the ratio of time in the fall of temperature between the

point where the insolubility and crystallizing moment of a compound begins to the increasing viscosity. Suppose a fluid rock magma, without crystallizations in it, comes to rest and the temperature begins to fall. At a certain point compounds, the ferro-magnesian ones let us say, commence to separate. The fall has been so gradual that only a few centers of crystallization have been set up. The magma retains its fluidity for each period and each mineral has a considerable time in which to grow, orienting and assimilating its substance around it or, to coin a phrase, it has a long *crystallization interval*. It is theoretically possible that if the conditions are stable for a long enough period each mineral in turn may exhaust itself in the magma before the next begins. Usually there are overlaps. Thus the process goes on until each has had its turn, the rock has crystallized and the *granular* structure is formed.

Other things being equal, the granularity depends on the length of the crystallization interval. In the case of the very siliceous magmas we must take into account another factor, *the viscosity*, which depends greatly on the included water vapor. If this is present in large amount the fluidity of the magma is enormously increased, and with it the radius of action of each crystallizing center, that is, the crystal has a free chance to grow, orient material and expand. On the other hand, if there is little or no water vapor present or it escapes before crystallization begins, the viscosity is greatly increased, the radius of action of each center is small, and, although the crystallization interval may be sufficiently long, the crystals are restrained in their growth, new centers are set up and the rock is fine-grained. Hence we may have coarse granular and fine granular rocks without porphyritic structure.*

In the case of the basic rocks, the included water vapor has no such function, their viscosity increases at a vastly slower rate for each degree in fall of temperature, hence the radius of action for equal crystallization intervals is much larger than in the acid rocks and we therefore find them quite coarse granular under the same conditions which have produced fine-grained structures in the acid ones. Other things being equal, the granularity depends on chemical composition, but there is also a limit to this, for it also depends on the number of crystallization centers which have been set up.

Porphyritic structure.—We can now consider the porphyritic structure. Suppose that an acid magma is injected with included water vapor and that the fall of temperature is comparatively rapid. The vapors escape rapidly and with the cooling and their escape the viscosity augments in a greatly

* See also Iddings' Crystallization of Igneous Rocks, Bulletin Phil. Soc., Washington, vol. xi, p. 105, 1889.

increasing ratio. This means shorter and shorter crystallization intervals for the various components as their periods commence. Thus the earlier ferro-magnesian components may have time to grow to considerable size while the increasing viscosity forces the feldspars and later components to be of very small size. Thus we may have a porphyritic structure with phenocrysts of the monogenetic type as a result of a single process of crystallization. It may be considered a sort of arrested or retarded granular structure.

But phenocrysts of the recurrent type evidently demand a further explanation and this is to be sought in two things. First the writer believes that the influence of mass action is of great importance and that compounds which are present in relatively large or predominant amount tend to set up centers of crystallization before what might otherwise be the proper period for that component. The rest of the process might go on as noted above and a porphyritic structure would be formed with phenocrysts of the recurrent type. Phenocrysts of the recurrent type would then consist of those minerals which are present in largest amount, and this is generally true. Such phenocrysts might form at any time and the earliest would be crystallizing during the whole period and might include the other constituents or exclude and orient them as previously noted.

Second, the writer is inclined to believe that too great regularity in the period of commencing crystallization of the different components has been ascribed to crystallizing magmas. That the different minerals *tend* to have their proper periods is undoubtedly so, but they do not always have them, and, for example, centers of feldspar crystallization may be set up at different times resulting in porphyritic structure as mentioned above. If we dissolve salt in water and allow the solution to crystallize in different beakers, we may obtain under apparently similar conditions a few large crystals, many small ones or a mixture of large and small. The conditions are of course not exactly similar but the differences may be very slight.

The more coarsely granular the rocks are, the more stable, and even the conditions under which they have crystallized and the less likelihood there is for the formation of phenocrysts—yet these do occasionally occur, as noted above in the porphyritic granites. In the fine-grained rocks these conditions are changed, the causes mentioned above become operative and a porphyritic structure is liable to result, as it commonly does.

Thus it seems most reasonable to regard the majority of phenocrysts as formed in place though in some cases they have evidently formed previously while the magma was ascending. Even in these cases they have probably been formed not long before.

Yale University, New Haven, Conn., December, 1898.

ART. XXIX.—*On the Occurrence, Origin and Chemical Composition of Chromite;* by J. H. PRATT.

Introduction.—In a recent paper* on the origin of the corundum associated with the peridotites in North Carolina, attention was called to the constant presence of the mineral chromite in these rocks. During the past summer the occurrence of chromite has been carefully studied and the occurrences in North Carolina have been examined in the field. As a result of these examinations the author has been led to adopt the theory that the chromite should be regarded as having been formed at the same time with the peridotite, i. e., as having been held in solution by the molten mass of the peridotite and crystallized out among the first minerals as the mass began to cool.

This theory is essentially the same as that advanced by the author† for the origin of the corundum associated with the peridotite rocks, and a similar line of reasoning has been used to substantiate the theory proposed.

Investigations concerning the igneous origin of some of the ores have been materially aided, during the recent years, by the able experiments of Morozewicz‡ and Lagorio§ and by researches that show us more clearly why we should regard a fused mass of rock as a liquid, having similar properties to an ordinary solution. The fused mass of rock is capable of holding different minerals in solution and as the molten mass begins to cool, these minerals would separate out not according to their fusibility but according to their solubility in the fused mass. The more basic minerals being the more insoluble would be the first to separate out, and as was mentioned in the paper already referred to, this crystallizing or solidifying out from the molten mass would take place first on its outer boundaries, for here it would cool first. Convection currents would tend to bring new supplies of material to the outer zone where crystallization takes place.

Occurrence.—With the exception of alluvial deposits, chromite has only been found in the peridotite and allied igneous basic magnesian rocks, or in the serpentines which have resulted from the alternation of these rocks. In the North Carolina peridotites chromite occurs more commonly as scattered grains or crystals, but it is also to be found in the form of imbedded masses near the boundaries of the lenticular bodies of dunite.

* This Journal, vol. vi, p. 49, July, 1898.
† This Journal, vol. vi, p. 50, July, 1898.
‡ Zeitschr für Kryst, vol. xxiv, p. 281, 1895.
§ Ibid., p. 285.

It does not occur in well defined veins, but is often in masses or pockets which apparently have no relation whatever to each other. But few writers on the occurrence of chromite have described the relation of the chromite deposits to the rock in which it is found. One or two have mentioned the chromite as being found near the eastern boundary of the serpentine or at the northern border of the serpentine belt, but no definite description of the occurrence could be obtained. The large deposits of chromite in North Carolina occur in the peridotite rock and near the contact of this rock with the enclosing gneiss. Also where there is but a small amount of chromite either in small pockets or in grains or crystals, these are more abundant near the contact and diminish in number toward the center of the mass of the peridotite.

Where these large deposits of chromite occur there has been no corundum or but very little found, and where we find the large deposits of the corundum there is a scarcity of chromite.

This constant occurrence of the chromite in rounded masses of varying proportions near the contact of the peridotite with the gneiss, its occurrence in the fresh as well as in the altered peridotite, indicate that the chromite has been held in solution in the molten mass of the peridotite when it was intruded into the country rock and that it separated out among the first minerals as the mass began to cool.

As has been said, the peridotite (dunite) magma holding in solution the chemical elements of the different minerals would be like a saturated liquid, and as it began to cool the minerals would separate or crystallize out, not according to their fusibility but according to the degree of their solubility in the molten magma. The more basic minerals, according to the general law of cooling and crystallizing magmas, being the less soluble, would therefore be the first to separate out. These would be the oxides containing no silica and in the present case would be the chromite, spinel and corundum. These minerals would solidify or crystallize out where the molten magma first began to cool, which would be at the contact of the mass with the country rock; convection currents would tend to bring new supplies of material to the outer boundary which would deposit its chromic oxide as chromites. This would account for all the irregularities of the chromite deposits: their pocket-like nature, the shooting off of apophyses from the main masses of the chromite into the peridotite, the widening and pinching of the chromite lodes, and the apparently non-relation or connection of one pocket of chromite with another. There has not been enough work done in the North Carolina chromite mines to demonstrate the exact position and relation of the chromite deposits to the gneiss or the country rock, and in the descrip-

tion of other chromite mines but little light has been thrown on this point.

The chromite would be concentrated near the borders of the peridotite in rounded masses, with offshoots penetrating into the peridotite. The line of contact near the gneiss would be sharp and nearly regular, while with the peridodite the contact would be very irregular.

In prospecting for either chromite or corundum the largest and richest deposits may be expected near the contact of the peridotite with the gneiss or other country rock.

Chemical composition.—Chromite has been analyzed from the following localities in North Carolina: Price's Creek, six miles southwest of Burnesville, Yancey County; Webster, Jackson County; and Corundum Hill, Macon County.

Pure material for analysis, showing no impurities when examined with the microscope, was readily obtained by hand picking.

The mineral was fused several times with bisulphate of potash, then taken up with hydrochloric acid and silica tested for. Iron, aluminium and chromium were precipitated with ammonia, the precipitation being made at least three times. Magnesium, calcium and manganese were determined in the filtrates by the usual methods.

The precipitate of the mixed oxides was dissolved in hydrochloric or nitric acid and the excess of acid evaporated. Sodium hydroxide was then added in excess and chlorine passed into the hot solution. The solution was acidified and the iron and aluminium precipitated twice with ammonia and weighed as mixed oxides. These mixed oxides containing a trace of chromium were fused with acid potassium sulphate, digested with water and acidified. One precipitation was made with ammonia to partially remove sulphates. This precipitate was dissolved in hydrochloric acid and treated as before, the iron and aluminium being obtained free from chromium. The iron was determined volumetrically.

To the filtrates containing the chromium, alcohol and hydrochloric acid were added and the solution digested for some time. The chromium was precipitated as hydroxide and weighed as Cr_2O_3. To ensure the purity of the precipitate, it was fused with four parts of sodium carbonate to one part of potassium nitrate, the fusion taken up with water and tested for magnesium.

A number of experiments were made to determine the ratio of ferric to ferrous oxide, but they were all unsatisfactory. By digesting the very finely powdered mineral in a mixture of hot concentrated hydrofluoric and sulphuric acid, in an atmosphere of carbon dioxide for half an hour, enough of the mineral was decomposed to show the presence of ferric oxide.

The analyses were made by Dr. Chas. Baskerville* and Dr. H. W. Foote.†

The result of the analyses were as follows:

	Price Creek.‡	Ratio.	Corundum Hill.‡	Ratio.	Webster §	Ratio.
Cr_2O_3	59·20	·386	57·80	·377	39·95	·261
Al_2O_3	7·15	·070	7·82	·076	29·28	·287
FeO	25·02	·347	25·68	·356	13·90	·193
MgO	4·42	·111	5·22	·131	17·31	·433
SiO_2	3·20	----	2·80	----	----	----
MnO	·92	----	·69	----	----	----

In the above analyses the ratio of the bivalent oxides to the trivalent oxides is uniformly high and can probably be accounted for by reason that some of the iron calculated as ferrous oxide was in the ferric state, as was proved in the Webster chromite.

Taking enough of the Cr_2O_3 and MgO to unite with the FeO and Al_2O_3 respectively to form the molecules $FeO \cdot Cr_2O_3$, and $MgO \cdot Al_2O_3$, there remains approximately enough of the Cr_2O_3 to unite with the excess of the MgO to form the molecule $MgO \cdot Cr_2O_3$. The nearer the ratio of the bivalent oxides equals that of the trivalent oxides, the nearer the excess of the Cr_2O_3 and MgO equal each other. The inability to determine the ratio of the ferrous to the ferric oxide in the above analyses prevents the obtaining of a sharp ratio in the excess of the Cr_2O_3 and MgO.

With the exception of two cases, in all the terrestrial chromite analyses examined, alumina and magnesium were invariably present, varying from a small per cent in some samples to others that showed the presence of more than 20 per cent of these oxides. In the above analyses and in most of the others examined, it was noticed that the magnesia usually varied with the alumina, those rich in alumina being correspondingly rich in magnesia.

This constant occurrence of magnesia and alumina in the chromite would seem to indicate that the molecule of the mineral now called chromite is not pure $FeO \cdot Cr_2O_3$ but is a combination of the three isomorphous molecules, $FeO \cdot Cr_2O_3$; $MgO \cdot Cr_2O_3$ and $MgO \cdot Al_2O_3$.

But two analyses of chromite (terrestrial) have been found that do not show the presence of magnesia and alumina, the first a magnetic chrome sand from Chester, Pa., analyzed by T. H. Garrett,‖ in which all the iron is calculated as ferric

* Of the Chemical Laboratory, N. C Geological Survey.
† Of the Sheffield Laboratory, Yale University.
‡ Baskerville. § Foote.
‖ This Journal, vol. xiv, p. 47, 1852.

oxide, and the second chromite from Vache Island, West Indies, analyzed by J. Clouet.*

	I (Garrett).	II (Clouet).
Cr_2O_3	41·55	51·53
FeO	----	48·46
Fe_2O_3	62·02	----
SiO_2	1·25	
	104·82	99·99

A greater part of the iron in Garrett's analyses is undoubtedly in the form of ferrous oxide, as is indicated by the high per cent obtained. From the above, it is seen that a pure chromite having the composition $FeO . Cr_2O_3$ is not common in nature.

The $MgO . Al_2O_3$ occurs nearly pure in nature as normal spinel. The normal $MgO . Cr_2O_3$ has not been found in nature, but, as indicated from the above analyses, there is good reason to believe that this molecule does exist, and we may expect to find normal $MgO . Cr_2O_3$ occurring as a definite mineral. Under this theory of the composition of the chromite, the formulæ for the three chromites described in this paper would be as follows:

1. Price Creek $10FeO . Cr_2O_3$; $MgO . Cr_2O_3$; $2MgO . Al_2O_3$.
2. Corundum Hill $9FeO . Cr_2O_3$; $MgO . Cr_2O_3$; $2MgO . Al_2O_3$.
3. Webster $FeO . Cr_2O_3$; $MgO . Cr_2O_3$; $2MgO . Al_2O_3$.

The first two formulæ will represent approximately those of the majority of the chromites that have been found, and they are approaching the normal chromite $FeO . Cr_2O_3$ as their limit.

As the $FeO . Cr_2O_3$ molecule decreases and the $MgO . Al_2O_3$ increases the mineral would approach normal spinel $MgO . Al_2O_3$ as its limit, the mineral picotite or chrome spinel being representative of a mineral near the spinel end.

M. E. Wadsworth,† in comparing the chromite with the picotite associated with peridotites, says:

"It is probable that picotite and chromite belong to the same mineral series, the term picotite being more commonly applied to the freshest states, and that of chromite to those forms more altered, and to the local aggregations arising from the migration of the chromic oxide during the alteration of the associated peridotite rocks. As a further extreme in the alteration a change to a more or less magnetite occurs." These conclusions are deduced from a microscopical study of these minerals."

* Ann. Chim. Phys., vol. xvi, pp. 90–100, 1869; and Wadsworth's Lithological Studies, appendix, p. iv.

† Lithological Studies, p. 184.

The author does not agree with Dr. Wadsworth that the chromite represents an altered product of a mineral, of which picotite is a purer form. The chromite is a mineral which suffers alteration but slightly and, as it is found at the present time, represents the original mineral and not an altered form. The difference in the microscopical properties can readily be accounted for by the difference in the chemical composition. With an increase in the ratio of the molecule, $MgO . Al_2O_3$ and a corresponding decrease in the molecule, $FeO . Cr_2O_3$, the more translucent the mineral will become.

These two minerals belong to the same group and are closely allied to each other, and they represent two primary minerals and not different stages in the alteration of another mineral.

In the analysis of the Webster chromite, the largest percentage of MgO was obtained and in the calculation of the ratios the formula was shown to be $FeO . Cr_2O_3$; $MgO . Cr_2O_3$; $2MgO . Al_2O_3$, this being the highest ratio of the molecule $MgO . Cr_2O_3$ of any chromite examined. The theoretical composition is here given, together with the analysis of the Webster mineral:

	Webster chromite found.	Theory for $2MgO . Al_2O_3$; $MgO . Cr_2O_3$; $FeO . Cr_2O_3$.
Cr_2O_3	39·95	40·90
Al_2O_3	29·28	30·44
FeO	13·90	10 75
MgO	17·31	17·91
	100·44	100·00

This analysis is similar to that described by Bock* for a "magnochromite" from Grochau, Silesia, which contained Cr_2O_3 40·78, Al_2O_3 29·92, FeO 15·30 and MgO 14·00.

In appearance this Webster chromite is different from any that has come under the author's observation, being much more of a coarse-grained appearance than ordinary chromite.

In order to designate this Webster chromite and others of similar composition, the author proposes the name, *Mitchellite*, in honor of the late Professor Elisha Mitchell of North Carolina.

N. C. Geological Survey, December, 1898.

*Zs. G. Ges., xxv, p. 394, 1873.

ART. XXX.—*The Influence of Hydrochloric Acid in Titrations by Sodium Thiosulphate, with special reference to the Estimation of Selenious Acid;* by JOHN T. NORTON, JR.

[Contributions from the Kent Chemical Laboratory of Yale University—LXXX.]

IN the method of Norris and Fay* for the iodometric determination of selenious acid, advantage is taken of a direct and unique action of sodium thiosulphate upon selenium dioxide in the presence of hydrochloric acid. Most excellent results are claimed for this method; but the explicit statement of the originators of the method, that the amount of hydrochloric acid present does not influence the result, provided the titration is made at the temperature of melting ice, is so extraordinary in view of generally accepted ideas in regard to the interaction of hydrochloric acid and sodium thiosulphate, as to suggest the necessity of careful investigation of this point.

Pickering,† in his investigation of the reaction between iodine and sodium thiosulphate, has shown that more iodine is required to oxidize the thiosulphate as the proportion of hydrochloric acid increases. He ascribed this effect to the formation of a sulphate, apparently, by the increased activity of the iodine, but the more rational explanation is that, although some sulphate is ultimately formed, the thiosulphate is first partially decomposed into free sulphur and sulphur dioxide. Finkener‡ and Mohr§ also mention the decomposing effect of free acid upon sodium thiosulphate.

The sodium thiosulphate used in the following experiments was taken in nearly decinormal solution and was standardized by running it into an approximately decinormal solution of iodine, the value of which had been determined by comparison with decinormal arsenious acid made from carefully resublimed arsenious oxide. In the experiments of Table I the solutions were stirred continuously and kept at a temperature of from 0° to 5° C., while the thiosulphate ran into the acidified liquid. The volume of the solution, though fixed at the beginning as given in the table, was considerably increased during the operation by the melting of the ice. Titrations were conducted as rapidly as possible to avoid the separation of sulphur, which is likely to occur, especially when the acid and thiosulphate are present in large quantities. A perusal of the table

* Am. Chem. Jour., vol. xviii, pp. 703.
† Jour. Chem. Soc, vol. xxxvii, pp. 135.
‡ Anal. Chem., 6 Aufl, pp. 620.
§ Titrirmethode, 6 Aufl., pp. 279.

shows that the influence of the hydrochloric acid upon the thiosulphate depends chiefly upon the amount of the thiosulphate present and afterwards upon the degree of dilu-

TABLE I.

Volume of liquid at beginning of titration.	$Na_2S_2O_3$ approximately $\frac{n}{10}$ taken.	Volume of $\frac{N}{10}$ iodine used in titration.				
		HCl=none.		=1 cm³.	=5 cm³.	=10 cm³.
cm³.	cm³.	cm³.		cm³.	cm³.	cm³.
100	30	30·25		30·75	30·76	31·2
200	"	30·22	mean=	30·21	30·56	31·4
300	"	30·20	30·22	30·22	31·03	30·9
400	"	30·21		30·20	30·20	30·55
500	"	30·20		30·20	30·21	30·55
100	25	25·29		25·32	25·98	25·70
200	"	25·28	mean=	25·34	25·40	25·45
300	"	25·29	25·27	25·41	25·38	25·83
400	"	25·27		25·24	25·30	25·63
500	"	25·22		25·23	25·40	25·30
100	20	20·15		20·17	20·33	20·23
200	"	20·20	mean=	20·13	20·27	20·23
300	"	20·21	20·15	20·15	20·20	20·17
400	"	20·20		20·10	20·27	20·07
500	"	20·10		20·10	20·17	20·13

tion and its own absolute quantity. Thus when 30^{cm^3} of sodium thiosulphate were employed the effect of 10^{cm^3} of acid is marked at all dilutions within the range of the experiments; the effect of 5^{cm^3} of acid is inappreciable only at a dilution of from 400 to 500^{cm^3}, and when 1^{cm^3} of acid is employed the effect is only perceptible at a volume of 100^{cm^3}. When 25^{cm^3} of the thiosulphate were used the influence of the acid is less marked; for at a dilution of 500^{cm^3} the effect of 10^{cm^3} of acid is not seen, and 20^{cm^3} of the thiosulphate may be present at any dilution down to 100^{cm^3} in the presence of as much as 10^{cm^3} of the acid, and even considerably more, as experiments not included in the table indicated.

The slight discrepancies which appear occasionally in the table were due, no doubt, to unavoidable differences in the time of action.

This influence of time upon the reaction between sodium thiosulphate iodine and hydrochloric acid comes out clearly in the following series of experiments, in which the thiosulphate was run into the acidified water, cooled to a temperature of from 0 to 5° C. by means of ice, the solution being allowed to

stand 5, 10, and 15 minutes. Sulphur was thrown down in nearly every case.

TABLE II.

Volume of the liquid at beginning of titration.	HCl sp. gr. (112) present.	$Na_2S_2O_3$ approximately $\frac{N}{10}$ taken.	Volume of $\frac{N}{10}$ iodine used in titration after standing.		
			5 min.	10 min.	15 min.
cm^3.	cm^3.	cm^3.	cm^3.	cm^3.	cm^3.
200	10	30	30·80	31·30	32·32
"	"	25	25·50	26·00	26·30
"	"	20	20·30	20·70	20·68

The results of the table emphasize sufficiently the necessity of proceeding as rapidly as possible with the titration of sodium thiosulphate by iodine in presence of hydrochloric acid, when the thiosulphate is present in considerable amount. As would be expected, the effect of temperature upon the reaction is also marked. In the following experiments the sodium thiosulphate was run into the acidified water, previously heated to the temperature indicated, and then titrated with iodine.

TABLE III.

Volume of liquid at beginning of titration.	HCl. sp. gr. (112) taken.	Temp. Centigrade.	$Na_2S_2O_3$ approximately. $\frac{N}{10}$ taken.	Volume of $\frac{N}{10}$ iodine used in titrations at different temperatures.
cm^3.	cm^3.	C.	cm^3.	cm^3.
400	10	6°	25	23·52
"	"	22°	"	23·73
"	"	34°	"	24·35
"	"	42°	"	24·5
"	"	54°	"	25
"	"	64°	"	26·1

From these results it is plain that the conditions under which considerable amounts of sodium thiosulphate are titrated in presence of hydrochloric acid must be carefully guarded when accuracy is a consideration. It is also apparent that in all cases the temperature should be reduced as nearly to 0° C. as possible and rapidity of titration by the iodine is an essential. So long as the thiosulphate present does not exceed 20^{cm^3} of the $\frac{n}{10}$ solution, rapid titration in cold solution proceeds with fair regularity in presence of hydrochloric acid up to 10^{cm^3} of the acid of sp. gr. 112. When, however, the amount of thio-

sulphate is greater than 20^{cm^3} of the $\frac{n}{10}$ solution, care as to the restriction of the acid and dilution of the solution becomes a necessity. Fortunately, in most analytical processes involving the use of the thiosulphate it is possible to add that reagent from the burette to the solution to be acted upon, so that it is destroyed normally as fast as it is introduced and the danger of interaction with the acid does not occur. In the process of Norris and Fay, however, the method involves the addition of an excess of the thiosulphate to the solution of selenious and hydrochloric acids, and thus the conditions prevail which demand care as to the relation of the acid, the thiosulphate and the degree of dilution. I have experimented, therefore, with this process under varying conditions.

The process of Norris and Fay for the iodometric determination of selenious acid consists briefly in treating the solution of that acid in ice water, in the presence of hydrochloric acid, with an excess of a $\frac{n}{10}$ solution of sodium thiosulphate and titrating back the excess of the thiosulphate with iodine. Four molecules of sodium thiosulphate act, apparently, upon one molecule of selenious acid according to a reaction which the authors propose to study.

The selenium dioxide used was made by dissolving presumably pure selenium in nitric acid and evaporating to dryness. The residue was then treated with water, and a little barium hydroxide was added to remove any sulphate which might be present. The solution was then filtered and the filtrate evaporated to dryness. The residue was mixed with four or five times its volume of dried pulverized pyrolusite, and the whole was put into a porcelain crucible and heated. The sublimate of selenium dioxide was carefully collected on a dry watch-glass and put into a drying bottle as quickly as possible. The pyrolusite prevents any reduction of the selenium dioxide to selenium and the product consisted of beautiful long white needles. This method of preparing the selenium dioxide, which has been used for some time in this laboratory, avoids contamination of the selenium dioxide by nitric acid or water, resulting from the decomposition of the latter, which would be possible in case this reagent were employed in the final sublimation, as is recommended by Norris and Fay. The hydrochloric acid used was of a sp. gr. 112, as recommended by the originators of the process. For the experiments of Table IV the dilution at the beginning was fixed at 400^{cm^3}, and this was increased in every case by the melting of the ice used to cool the liquid. A glance at the preceding part of this paper

will show that at this degree of dilution the hydrochloric acid present has the least effect.

TABLE IV.

	Amount SeO_2 taken. grm.	HCl sp. gr. 112 taken. cm^3.	Volume at beginning of titration. cm^3.	Excess $Na_2S_2O_3$ employed. cm^3.	SeO_2 found. grm.	Error. grm.	
(1)	·0616	10	400	2·28	0·0625	0·0009 +	
(2)	·0628	"	"	7·11	0·0631	0·0003 +	
(3)	·0508	"	"	11·4	0·0511	0·0003 +	
(4)	·0587	"	"	12·8	0·0594	0·0007 +	mean
(5)	·0807	"	"	15·3	0·0813	0·0006 +	·00005 +
(6)	·0633	"	"	20·85	0·0638	0·0005 +	
(7)	·0682	25	"	1·11	0·0685	0·0003 +	
(8)	·0779	"	"	1.35	0·0788	0·0009 +	
(9)	·0465	"	"	18·93	0·0469	0·0004 +	

These results, while not so good as those obtained by Norris and Fay, are satisfactory and show that at this degree of dilution the process is accurate. These results accord closely with those contained in Table I. At a dilution of 400^{cm^3} or in the presence of only 20^{cm^3} of sodium thiosulphate in excess the hydrochloric acid present had no perceptible effect. Of course, it must be kept in mind that the hydrochloric acid acts only upon the excess of thiosulphate which is not taken up by the selenium dioxide. The slight constant plus error in these results cannot be accounted for by errors in the standards; they were all carefully determined. Another preparation of selenium dioxide was made, starting with pure selenium carefully precipitated by sulphurous acid, before putting it through the course of treatment previously described, and the results obtained by the action of the sodium thiosulphate recorded in Table V agree closely with those of the preceding table.

TABLE V.

	Amount SeO_2 taken. grm.	HCl sp. gr. 112. cm^3.	H_2O at beginning. cm^3.	$Na_2S_2O_3$ in excess. cm^3.	SeO_2 found. grm.	Error. grm.
(1)	·0562	10	400	9·52	·0566	·0004 +
(2)	·0651	25	"	11·20	·0655	·0004 +

The next step was to determine the effect of diminishing the dilution and of varying the strength of acid. The following table gives the results of my experiments.

TABLE VI.

	Amount of SeO_2 taken. grm.	Volume of H_2O at beginning. cm^3	HCl sp. gr. (112). cm^3	Excess of $Na_2S_2O_3$. cm^3	SeO_2 taken. grm.	Error. grm.
(1)	·1042	200	5	24·16	·1041	·0001—
(2)	·0611	"	10	13·3	·0611	·0000±
(3)	·0850	"	10	21·9	·0828	·0022—
(4)	·0757	"	25	13·07	·0749	·0008—
(5)	·0540	"	25	21·02	·0522	·0018—
(6)	·0674	300	5	10·04	·0679	·0005+
(7)	·2416	400	5	15·9	·2424	·0008+

It is apparent that at the dilution of 200^{cm^3} we run into difficulties, and the greater the excess of thiosulphate present the greater is the error. When the amount of sodium thiosulphate exceeds 20^{cm^3} a reduction in the amount of acid to 5^{cm^3} is plainly of advantage, as is shown in a comparison of Exps. (1), (3), and (5), and is not disadvantageous at larger dilutions and with smaller amounts of the thiosulphate, as shown in Exps. (6) and (7). The necessity of placing some limits on the method of Norris and Fay has now, I think, been established. The excess of the thiosulphate must be carefully regulated, as well as the temperature. If one has knowledge of the approximate amount of selenious acid in solution, this is not a matter of great difficulty, and things should be so arranged that no more than 20^{cm^3} of the $\frac{n}{10}$ thiosulphate should ever be present in excess of the amount necessary to reduce the selenious acid. If this limit —amounting to $0{\cdot}0400^{cm}$ of SeO_2— is placed upon the thiosulphate, so much as 10^{cm^3} of hydrochloric acid (sp. gr. 112) may be present without endangering the accuracy of the process, provided the solution is diluted to 400^{cm^3} at the outset; if only 5^{cm^3} of hydrochloric acid are present, the volume at the beginning may be reduced with safety to 200^{cm^3}. At all events, 5^{cm^3} of the hydrochloric acid are amply sufficient to bring about the reaction between the thiosulphate and the selenium at any dilution within the range of my experiments. With these precautions taken, the process of Norris and Fay is simple, rapid and accurate; without them, as the experimental results indicate, errors of considerable amount may enter.

According to the method of * Muthmann and Shafer, the determination of selenious acid is effected by the simple addition of potassium iodide to the acidulated solution of selenious

* Berichte d. d. Chem. Gesell., xxvi, 1008.

acid, and the iodine set free is titrated with sodium thiosulphate. In this procedure the thiosulphate is taken up by the iodine as it is added to the solution, so that the danger of any action between the thiosulphate and the acid is out of the question. It was shown in a former paper from this laboratory * that this simple method is inaccurate on account of the incompleteness of reduction in the cold and in presence of the iodine evolved. In a later article also from this laboratory † it was shown that selenium may be completely precipitated and determined with accuracy gravimetrically provided the amount of potassium iodide employed is enormously in excess of that theoretically required. This suggests naturally the trial of very large excesses of potassium iodide in the process of Muthmann and Shafer. The details of experiments made in this manner are given in the following table.

TABLE VII.

	SeO_2 used. grm.	KI. grm.	Vol. of solution. cm^3	HCl sp. gr. (112). cm^3	ScO_2 found. grm.	Error. grm.
(1)	·0553	10	150	10	·0558	·0005 +
(2)	·0574	5	"	"	·0567	·0007 —
(3)	·0683	5	"	"	·0683	·0000 ±
(4)	·0487	5	"	"	·0484	·0003 —
(5)	·2617	10	"	"	·2589	·0028 —

It is obvious that for small quantities of selenium dioxide the accuracy of the process is very much increased by the use of large amounts of iodide, though, of course, the difficulty in reading the end reaction due to the presence of precipitated red selenium still remains; but the process is still inaccurate when large amounts of selenium dioxide are employed.

In conclusion I wish to thank Prof. F. A. Gooch for his kind advice and assistance.

* This Journal, Gooch and Reynolds, vol. I, 254.
† Peirce, this Journal, vol. i, 1896, p. 416.

ART. XXXI.—*Some Rock-forming Biotites and Amphiboles;** by H. W. TURNER, with analyses by W. F. HILLEBRAND, H. N. STOKES, and WILLIAM VALENTINE.

THE minerals referred to in this paper were separated from the rocks containing them by means of the Thoulet solution. The analyses were made in the laboratory of the U. S. Geological Survey, the object being to furnish a basis for calculating the molecular composition of the rocks containing them. All of the material was fresh and sensibly free from foreign particles. The powder analyzed in each case was examined microscopically and such impurities as were found are given. Samples of minerals as well as chips of the rocks containing them will be sent to any one who is investigating rock-forming minerals, upon request. The specimens came from the Sierra Nevada in all cases.

Biotite.

Biotite No. 2136 is from the biotite-granite at the base of El Capitan in Yosemite Valley. It is quite black in color, as seen with a hand lens, but under the microscope is brown. This biotite-granite forms large areas in the granitic complex of the Sierra Nevada, and is quite uniform in appearance and composition at nearly all points where I have seen it. The biotite which it everywhere contains as an essential constituent, is quite the same in color and degree of pleochroism in the many thin sections examined, and the analysis given below may be fairly assumed to represent in general the composition of the biotite of this granite. Biotite-granite 2136 contains quartz > plagioclase > orthoclase > biotite > magnetite > titanite > apatite > zircon, the last four minerals being merely accessories. The aplitic granites that cut the other granites in dikes likewise contain a very similar biotite in small amount.

A microscopic examination of the material analyzed, as well as the mere fact that phosphorus pentoxide is present, showed that there were apatite prisms mixed with the biotite. The analysis was therefore recalculated and the P_2O_5 (·20) taken out together with the CaO (·26) required by the P_2O_5 to form apatite. The H_2O below 110° C. is likewise left out in this recalculation since it was no doubt adventitious.

Biotite No. 1751 S.N. is from a quartz-monzonite collected about 1 klm. southwest of Blood's Station, Alpine County, in the Big Trees quadrangle. The material analyzed was found, on microscopic examination, to contain occasional white grains,

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Analyses of Biotite, and the containing rocks.

	Biotite 2136.	2136 recalculated.	Biotite-granite 21·36.	Biotite 1751.	Quartz-monzonite 1751.	Biotite 1743.	Gneiss 1743.	Biotite 2652 S.N.
SiO_2	35·64	36·02	71·08	35·62	66·91	36·62	51·5	35·75
TiO_2	1·12	1·13	·22	2·61	------	3·03	---------	3·16
ZrO_2	---------	---------	·08	---------	------	------	---------	none
Al_2O_3	18·62	18·81	15·90	15·24	------	14·37	---------	14·70
Cr_2O_5	---------	---------	---------	---------	------	------	---------	trace
V_2O_3	---------	---------	---------	---------	------	------	·08	·05
Fe_2O_3	5·54	5·60	·62	4·69	------	4·04	---------	4·65
FeO	14·60	14·75	1·31	13·67	------	17·09	---------	14·08
MnO	·79	·80	·15	·74	------	·40	---------	·45
NiO and CoO	---------	---------	---------	---------	------	------	---------	·02
CaO	·90	·65	2·60	·95	3·51	1·48	---------	·17
SrO	none	none	·02	trace	------	trace	---------	?
BaO	trace	trace	·04	·26	------	·33	---------	·12
MgO	9·72	9·82	·54	12·70	------	9·68	---------	12·37
K_2O	9·22	9·32	4·08	7·72	3·13	8·20	---------	9·19
Na_2O	·38	·38	3·54	·50	3·59	·45	---------	·32
Li_2O	trace	trace	trace	trace	trace	trace	---------	
H_2O below 110° C.	·48	---------	none	·94	------	·90	---------	1·03*
H_2O above 110° C.	2·54	2·57	·30	4·36	------	3·26	---------	3·64*
P_2O_5	·20	---------	·10	none	------	none	---------	·03
SO_3	---------	---------	none	---------	------	------	---------	------
Cl	---------	---------	·02	---------	------	------	---------	------
F	·26	·26	CO_2 trace	none	------	·10	------ --	·17
Total	100·01	100·11	100·60	100·00		99·95		99·90
Oxygen = F	·11	·11				·04		·07
	99·90	100·00		100·00		99·91		99·83
Analyst	Valentine		Valentine	Valentine	Stokes	Valentine	Hillebrand	Hillebrand

* Determined at 105° C.

probably feldspar. The impurities, however, form such a minute portion of the material that the analysis may be considered as sufficiently correct for use in calculating the constituents of the granitic rock of which it forms a part. The mica is quite black in color, as seen with a hand lens. Under the microscope it is a darker brown than the biotite of the biotite-granite. This biotite is characteristic of the granodiorite and quartz-diorite series, and of the quartz-monzonite. It contains more magnesia than any other of the biotites analyzed but nearly the same as amphibole 2652, also from quartz-monzonite. Dr. Hillebrand examined specimen 1751 and the biotite from it for vanadium. He found that the rock contained ·012 per cent of V_2O_3 and the biotite ·066 per cent. Quartz-monzonite 1751 is composed of plagioclase>quartz> orthoclase>biotite>amphibole. There are present as accessories titanite, apatite, and iron ore.

Biotite No. 1743 S.N. is from a pyroxenic gneiss from the south bank of the North Mokelumne River, about 1 klm. up stream from the mouth of Bear River, in the Big Trees quadrangle. The material analyzed was found, on microscopic examination, to contain occasional grains of amphibole, but these probably do not sensibly affect the result. This biotite is reddish-brown in color and quite similar to the biotite so often found in contact metamorphic rocks. Dr. Hillebrand subsequently tested the material for vanadium and found gneiss 1743 contained ·08 per cent V_2O_3, and the biotite from it ·127 per cent. Gneiss 1743 is composed of plagioclase, reddish-brown biotite, greenish-brown amphibole, quartz, pyroxene, titanite, magnetite, apatite, and pyrrhotite, the relative abundance being approximately indicated by the order in which the constituents are enumerated.

Biotite No. 2652 is from a quartz-monzonite from a block by the Tioga road southeast of Mt. Hoffmann in the Mt. Dana quadrangle. The amphibole 2652 analyzed is from the same block, and both were separated as well as analyzed by Dr. Hillebrand. The block above referred to was far richer in amphibole and biotite than is usually the case with the quartz-monzonite of the region. There is thus a possibility that these minerals may differ somewhat in composition from the same minerals where they occur evenly distributed through the magma. An examination of the powder analyzed shows on one slide a very few foreign particles, namely, apatite and amphibole. The apatite should of course be deducted from the analysis as well as the water below 105° C. Dr. Hillebrand found that the mica contains no rare earth, zinc, or metals of the H_2S group. The specific gravity of biotite 2652 at 21° C. is 3·05. Quartz-monzonite 2652 was not analyzed, but for

purposes of comparison No. 2179, given in the table of amphibole analyses, may be substituted, as this is from the same area and represents the average rock.

A comparison of the biotite analyses given in the table with those of the rocks from which the micas were obtained, does not suggest any very definite relations. These micas are all quite similar in composition. It may be noted, however, that the biotite richest in alumina and alkali is from the most acid rock of the series, the biotite-granite (No. 2136). This rock contains no amphibole. Biotites 1751 and 2652 are richer in magnesia. Both of these are very similar in composition as well as in color and pleochroism, and both of them are associated with amphibole.

Analyses of Amphibole and the containing rocks.

	Amphibole 1970	Gabbro 1970.	Amphibole 2652.	Quartz-monzonite 2199.	Amphibole Donegal granite.	Donegal granite.
SiO_2	46·08	47·27	47·49	66·83	47·25	58·04
TiO_2	·77	·92	1·21	·54	------	------
ZrO_2	------	------	none	·04	------	------
Al_2O_3	10·56	20·82	7·07	15·24	5·65	16·08
Cr_2O_3	------	faint trace*	------	------	------	------
V_2O_3	------	·02	·04	------	------	------
Fe_2O_3	2·81	1·85	4·88	2·73	19·11	8·27
FeO	8·30	4·26	10·69	1·66	·94	0·45
MnO	·15	trace	·51	·10	1·70	1·12
NiO and CoO	------	none	·02	------	------	------
CaO	12·64	13·02	11·92	3·59	11·76	6·52
SrO	none	trace	none	·03	------	------
BaO	none	none	none	·11	------	------
MgO	14·40	6·44	13·06	1·63	11·26	2·94
K_2O	·34	·22	·49	4·46	1·04	2·21
Na_2O	1·62	2 75	·75	3 10	·98	4·65
Li_2O	none	none	trace	trace	------	------
H_2O below 110° C.	·17	·08	†	none	------	------
H_2O above 110° C.	1·97	1·27	1·86	·56	------	------
P_2O_5	·18	·74	none	·18	------	------
CO_2	------	none	------	trace	------	------
FeS_2	------	·20	------	------	------	------
SO_3	------	------	------	none	------	------
Cl	------	trace	------	·02	------	------
F	none	------	·06	------	------	------
Total	99·99	99·86	100·05	100·82	99·69	100·28
Analyst	Valentine	Stokes	Hillebrand	Valentine	Haughton	Haughton.

An examination of the powder of amphibole 1970 shows that it contains a few grains of labradorite but otherwise appears

* Cr_2O_3 and V_2O_3 determined by Dr. Hillebrand.

† Dried at 105° C. before analyzing. No rare earths or zinc present.

to be quite pure. The phosphorus pentoxide (P_2O_5) shown in the analysis must, however, be ascribed to apatite, and this should be deducted from the amphibole analysis together with a corresponding amount of lime. In addition minute black grains may be noted in the amphibole itself. These are probably magnetite, but the amount thus included must be small, since the powder was treated with an electro-magnet and the more highly magnetic grains removed. No titanite or other titaniferous mineral were found in the thin sections of gabbro 1970 or in the amphibole powder. The titanic oxide (TiO_2) shown in the analysis therefore probably belongs to the amphibole. The pleochroism is strong in brown and greenish brown colors with large extinction angle.

Amphibole-gabbro 1970 is from Beaver Creek about 18 klm. east of Big Trees P. O. in the Big Trees quadrangle. It is composed chiefly of labradorite and amphibole but contains a little pyrite and pyrrhotite.

Amphibole 2652 is exceptionally pure. It is pleochroic in dark green tints with large extinction angle. There are some minute black grains included in the amphibole. These are probably magnetite. One foreign particle only was noted in a slide of the powder. As before stated, this amphibole comes from the same block of quartz-monzonite as biotite 2652. The specific gravity of amphibole 2652 at 21·5° C. is 3·203. Analysis 2179 is that of an average quartz-monzonite of the region. It is well known that the metasilicates of rocks rich in alkalies are sometimes themselves rich in alkali. This relation does not appear to obtain in the case of amphiboles 1970 and 2652, the former of which comes from a basic rock poor in alkali, and the latter from an acid rock rather rich in alkali. yet there is more alkali in the amphibole from the basic than in that from the acid rock.

There is also added to the table an analysis of an amphibole from the Donegal granite* as well as one of the granite itself. It is evident from the analysis of this granite that the rock is really a quartz-diorite or granodiorite and not a true granite. The biotite from the Donegal granite is remarkable for the very high content of ferric iron—19·11 per cent.

* Haughton, Quart. Jour. Geol. Soc. Lond., vol. xviii, 1862, p. 416.

ART. XXXII.—*On one little known and one hitherto unknown species of Saurocephalus;* by O. P. HAY.

THE fish *Saurocephalus lanciformis* was first described and named by Dr. Richard Harlan in 1824.* This description and the accompanying figures were reprinted in 1835 in the same author's Medical and Physical Researches.† The specimen on which the genus and species were based had been collected about twenty years previously, by Lewis and Clark, at some locality probably in northeastern Nebraska. It consisted of the greater portion of the left maxilla; but was described by Harlan as belonging to the lower jaw. He also regarded it as having belonged to a reptile allied to *Ichthyosaurus*. Louis Agassiz first recognized the ichthyic nature of the remains‡ (although he confounded them with an entirely distinct species); and his conclusions were confirmed by Richard Owen.§ Dr. Leidy‖ corrected Agassiz's errors, and gave more accurate descriptions and figures of the maxillary than had been furnished by Harlan.

No remains of Harlan's species, other than the maxillary referred to, have hitherto been described. Dr. E. W. Hilgard¶ has reported the species as occurring in the Vicksburg group of the Eocene, but the identification was undoubtedly erroneous. Dr. William Spillman** has also included this species in his list of fossils belonging to the Tombigbee greensand of the Cretaceous at Columbus, Miss. Although this identification is less improbable than the former, we have nothing to confirm its correctness.

Notwithstanding the scantiness of the material belonging to the type species, our knowledge of the genus *Saurocephalus* has been greatly increased through the descriptions of closely related and more perfectly preserved species. For this additional knowledge we are indebted to Cope and Newton, and more recently to Alban Stewart, of the University of Kansas.

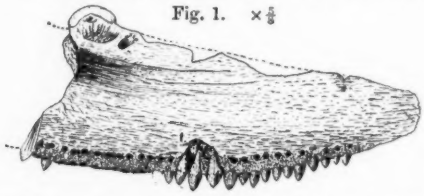
For some time I have had in my possession some remains which on examination prove, in my judgment, to belong to Harlan's species. This material was collected for me in the region of Butte Creek cañon, south of Wallace, Kan.; and the horizon is undoubtedly that of the Niobrara Cretaceous. My material consists of both the mandibles, the right maxilla, the pterygo-palatine arch and a few other bones.

The maxillary (fig. 1) is rather short and deep. The portion belonging in front of the palatine condyle is missing; but the condyle itself is present. The alveolar border is somewhat

* Jour. Acad. Nat. Sci. Phila. [1], iii, pp. 331–337, pl. xii, figs. 1–5.
† Med. Phys. Res., pp. 362–366, pl., figs. 1–5.
‡ Poiss. Foss., v, p. 102. § Odontography, p. 130, pl. 55.
‖ Trans. Amer. Philos. Soc., 1857, xi, pp. 91–95, pl. vi, figs. 8–11.
¶ Report Geol. and Agric. Mississippi, 1860, p. 142. ** Op. cit., p. 389.

curved, and is occupied by compressed sharp-edged teeth. Of these there are present twenty-eight; but if we restore the bone, as we can safely do, I believe, by aid of Stewart's figures

Fig. 1. ×⅝



of *S. dentatus*,* we may conclude that there were originally thirty-four teeth, possibly one or two less. The root of the most anterior tooth has been exposed by the fracture, and its fang is seen to be distinctly faceted; so that it presents just such an appearance as the tooth of *S. lanciformis* figured by Leidy.† The roots of teeth situated more posteriorly whose fangs have been exposed by a tool are similarly faceted. Cope states‡ that *S. lanciformis* is to be distinguished from his *S. arapahovius*, by the lack of facets on the roots of the teeth of the latter.

Leidy estimated that the maxilla in his hands had supported only twenty-six or twenty-eight teeth, and he was probably correct. That maxilla, a larger one than the one in my possession, seems to have been broken just behind the palatine condyle. If now we take from Leidy's drawing the width of the bone at this point and apply it to the alveolar border, we find that it includes ten teeth; the width of my own specimen includes thirteen teeth. It is not impossible, however, that the specimen figured by Leidy had been broken away some little distance behind the condyle. At any rate, I do not believe that the difference of a few teeth, other things being alike, would justify us in regarding the specimens as belonging to different species.

As in the case of the original specimen there is a shallow groove running along the mesial surface of the maxilla, about 5^{mm} from the alveolar border, and from this groove foramina, one for each tooth, enter the bone.

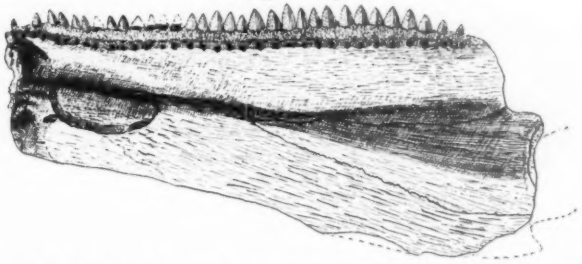
Depth of maxillary at palatine condyle	38^{mm}
Distance from anterior end of palatine condyle to hinder end of maxillary	85^{mm}

The right mandible is shown in fig. 2, five-eighths the natural size and showing the mesial surface. The alveolar border is straight and supports thirty-four teeth, of which those occupying the middle of the border are the largest. In general, they are larger than the teeth of the upper jaw. The line

* Kan. Univ. Quart., vii, p. 25, pl. i, figs. 3*a*, 4*a*.
† Trans. Amer. Philos. Soc., xi, pl. vi, fig. 9. ‡ Cretaceous Vertebrata, p. 216.

which spans thirteen teeth in the maxilla spans ten in the dentary. At the proximal end of the mandible there must have been a process of the dermarticulare, as in related forms; but in the specimen figured it is hidden by the overlying

Fig. 2. $\times \frac{1}{3}$



ceratohyal, which is not shown in the figure. At the anterior end of the mesial face of the dentary there is found a broad surface, rough with processes and pits, an indication that the two dentaries were strongly bound together. The extreme anterior end of each dentary is occupied by a surface to which was evidently attached such a predentary as Stewart has described as belonging to several related species. A groove and a row of foramina are present on the median face of the dentary.

Length of alveolar border	112mm
Length of mandible from cotylus ..	130
Depth of mandible at last tooth ...	56
Depth of mandible at symphysis ..	34

Fig. 3 represents, five-eighths the natural size, the pterygo-palatine arch seen from within. A triangular piece is missing from the anterior end, and the lower end of the ectopterygoid,

Fig. 3 $\times \frac{1}{3}$

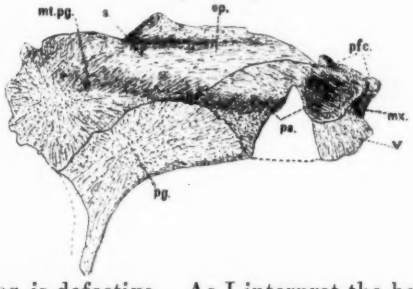
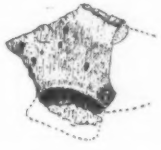


Fig. 4. $\times \frac{1}{2}$



pg, is defective. As I interpret the bones, the arch is remarkable for the large size of the palatine, *pa*. While the sutures which are represented in the figure are very distinct, I am wholly unable to find one separating the entopterygoid, *ep*, from the metopterygoid *mt. pg*. On the upper border of the

arch, at the point indicated by the line *s*, there appears to be an indication of a suture. If such it is, it probably extends downwards to a point near the hinder end of the palatine. The arrangement of the bones is quite different from that found by myself in *Xiphactinus*.*

At the lower border of the anterior end of the palatine there is a broad surface, *v*, which was probably in contact with an articulating surface on the vomer. The notch seen in the anterior end is occupied by another articulatory surface, *mx*, for the anterior palatine condyle of the maxilla. The anterior end of the upper border furnished an articulation, *pfc*, with the prefrontal, but this is elongated and rough, not broad and smooth, as it is in *Xiphactinus*.

Anteriorly the palatine is thick and strong. On its outer surface this portion is finely vermiculated above, while the lower portion furnishes a concave articulation for the condyle of the maxilla. The general appearance of this portion may be seen from fig. 4, which represents the palatine of the next species. Below the concave surface for the palatine condyle of the maxilla there is seen a broad rough surface which must have been applied to the inner face of the maxilla. The greater portion of this is wanting in the specimen shown in fig. 4. Its limits are indicated by the dotted line. On the outer face of the metapterygoid, from the highest point seen in fig. 3 there runs downward and backward a sharp ridge which evidently bounded the orbit below. The portion of the metapterygoid above and mesiad of this ridge formed the floor of the orbit. This indicates that the orbit was placed well backward. I find no satisfactory evidences of the presence of teeth on the pterygoid and palatine bones. If we shall add to the maxillary the probable antero-posterior extent of the premaxillary, we shall find that it is approximately equal to the length of the lower jaw. Hence the latter did not project beyond the upper jaw as it did in the case of those species which Stewart has referred to the genus *Saurodon*.

Two characters seem to distinguish *Saurodon* from *Saurocephalus*, viz.: the presence of notches, instead of foramina, for the successional teeth and the projection of the lower jaw beyond the snout of the fish. I have been inclined to believe that the presence of these two characters is sufficient to distinguish *Saurodon* as distinct. However, I observe in some specimens of this supposed genus that some of the notches become closed into foramina; and we can easily imagine all gradations between notches and foramina high above the alveolar margin. Moreover, it is probable that the other character will fail. Recently Mr. Stewart† has published figures, without description, of remains which he refers to Cope's *Sauro-*

* Zoolog. Bull., ii, 1898, p. 39, fig. 7.

† Kan. Univ. Quart., vii, pl. xvi, figs. 4, 5.

don phlebotomus. Mandible and maxilla are shown. Measurements show that the maxilla, without the premaxillary, is nearly as long as the alveolar border of the mandible, so that it is almost certain that in this species there was no projection of the dentary beyond the snout. It seems probable therefore that *Saurodon* must be abandoned.

I present here (fig. 5) the right maxilla and the premaxillary (fig. 4) of another species of *Saurocephalus*, which I regard as yet undescribed. It is especially distinguished from described species by its elongated maxillary bone. To illustrate this, I compare it with Mr. Stewart's *S. dentatus*, which is itself a species with a rather long maxilla. In *S. dentatus* the total

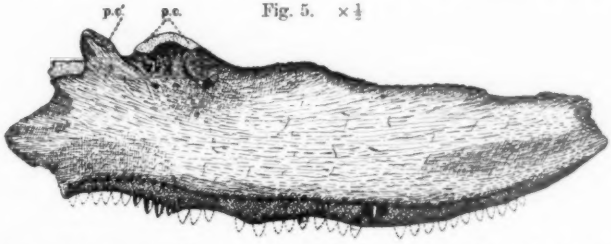


Fig. 5. $\times \frac{1}{2}$

length of the maxilla is 142^{mm}, its height at the palatine condyle 48·5^{mm}. My specimen has the same height at the condyle; but the total length is 172^{mm}, a difference of 30^{mm}, equal to 21 per cent of the shorter maxilla. My species, therefore, probably had a relatively slender head and a larger mouth than had *S. dentatus*.

In the maxilla figured I count alveoli for thirty-seven teeth; but in the maxilla of the other side, somewhat broken, the teeth extend backward somewhat farther; so that there must have been forty. At some time in the career of its owner the right maxilla has been fractured obliquely across its middle, and this accident has affected the neighboring teeth. One of these has thus become exposed nearly half-way to the tip of the fang. This exposure reveals the fact that the fang is faceted, as it is in *S. lanciformis*. The great length of the maxilla distinguishes this species from both *S. lanciformis* and *S. dentatus*, and the facets on the teeth distinguish it from Cope's *S. arapahovius*. Mr. Stewart has not described the condition of the fang of the teeth of his *S. dentatus*.

In fig. 5 *p. c* represents the palatine condyle; *p. c'*, the anterior palatine condyle which was applied to a surface like that shown in figure 3 at *mx*.

I propose to call the fish above described *Saurocephalus pamphagus*.*

* Inde ruunt alii rapida velocius aura,
Pamphagus et . . . . . .
Ovid, Met., Bk. iii, l. 209.

It has been supposed that the foramina, situated one opposite each tooth and on the mesial face of the maxilla and of the dentary, are for the transmission of nerves and vessels to the teeth. Richard Owen* seems not to have so regarded these foramina. He believed that they "lead to the cavities containing the germs of the successional teeth." The latter probably began their development in, or at the bottom of, these foramina; but they soon passed more deeply into the bone. In fig. 1 at *t* there is found a developing tooth whose tip is on a level with the row of foramina: but its root extends high up into the bone. Nerves and vessels entering the tooth by way of the foramina alluded to would have to take a very tortuous course. The functional tooth immediately below the young tooth figured seems already to have suffered some reduction of its fang.

The germs of the teeth of the *Saurocephalidæ* did not gain a lodgment in the bones of the jaws in the same way that the teeth of the higher vertebrates did. In the latter the fangs were first planted in grooves in the dental borders of the bones; and we must suppose that these grooves, at first shallow, have, in successive generations, deepened and become portioned off to form sockets. In the *Saurocephalidæ* the teeth, developing originally on the dental border, have gradually migrated away from this border, on the mesial face of the supporting bones, and, by means of the foramina described above, have made their way through the mesial wall of the sockets. The notches found in the species referred to *Saurodon* show the earliest stages of this migration.

The distinguished palæo-ichthyologist, Mr. A. S. Woodward, has recently kindly called my attention to a suggestion made by Prof. E. D. Cope that the *Saurocephalidæ* are closely related to the *Chirocentridæ*, represented by the large *Chirocentrus dorab* of the Chinese and Indian seas. I have unfortunately had no opportunity to study a skeleton of this fish; but, judging from the figures of the fish found in Cuvier and Valenciennes, pl. 565, and in Day's Fishes of India, pl. clxvi, fig. 3, its external appearance must be much like that of the extinct *Xiphactinus*. Nevertheless, we have no intimations that the teeth of *Chirocentrus* are fixed to the jaws in any way different from those of ordinary fishes. The fixation of the teeth in sockets is an unusual thing among fishes; and this character alone, it appears to me, is sufficient to remove *Xiphactinus* and its allies from the Chirocentridæ, although not necessarily to a great distance. I suspect that the *Saurocephalidæ* will, when they are better known, show distinctive characters in the vertebral column also.

* Odontography, p. 131.

ART. XXXIII.—*A Study of Some American Fossil Cycads.* Part II. *The Leaf Structure of Cycadeoidea;* by G. R. WIELAND. (With Plate VII.)

Introduction.

IT is generally conceded that the Cycads culminated in the Jurassic, and formed the principal plant life of that time. Nevertheless, the abundant and widely distributed fossil remains of this vegetation consist almost entirely of disconnected and scattered trunks, leaves, and occasional fruits, which have been described under separate generic and specific names. So uniformly is this true that Count Solms-Laubach[9]* mentions an individual of *Zamites gigas*, Morr., from the upper Jurassic sandstone of Yorkshire, England, as the only cycad known to him, whose stem with the leaves attached may be identified with certainty. This specimen, now in the Paris Museum, is figured by Saporta,[4] and in leaf and habit is said to recall *Stangeria* most nearly.

There has, therefore, been no sufficient means of correlating the various genera and species founded on isolated parts,—a fact which now makes especially important a determination of both trunk and leaf characters when united in a single individual. For this reason it is fortunate that not only the leaf and its prefoliation, but also the accompanying floral characters, may be completely determined in a number of the unusually perfect cycadean trunks now in the Yale collection, though but a single one is considered in this paper.

Prefoliation of Cycadeoidea.

The subject of the present, as well as of the preceding, preliminary study is afforded by the type specimen of *Cycadeoidea ingens*, Ward, a photograph of which has been already given. As previously mentioned, this fine male trunk bears on its summit, above the series of flower buds, a crown of young leaves imbedded in fine scales, or ramentum. It would seem that, having formed its blossoms, this cycad was again preparing to put forth its energies in the unfolding of an additional series of leaves, about twenty in number. Happening to be fossilized at such a critical time in its life, under the most favorable conditions, there has been preserved a wealth of characters scarcely equalled by any Mesozoic plant of which there is a record. This specimen alone affords all the material required for a restoration.

* The numbers refer to the list of papers given in Part I of these studies. This Journal, March, 1899, pp. 219–226, Plates III, IV.

A careful examination of the summit of the trunk showed that, as found in the field, it had been subjected to the erosive action of sand-laden winds which had partially exposed several transverse sections of the tips of young leaves. It was found that these belonged to a circularly placed series just ready to emerge at a distance of from 5 to 8 cm from the apex. Several pairs of these leaves enveloped in ramentum were removed for study, and the disposition of their parts with reference to the trunk determined from longitudinal, transverse, and tangential sections.

As so removed, each rachis with its attached pinnules formed an erect subcylindrical, or spindle-shaped, body, 6 cm in length, with a long diameter of 15 mm coinciding with the radius of the trunk, and a short diameter of 12 mm at right angles to it. . The rachis was erect and situated distally on the long diameter. It bore the pinnules inclined inwards in two imbricating ranks, formed by the two rows of pinnæ on each leaf, in such manner that their upper surfaces all faced towards the axis of the trunk.

A clearer perception of the arrangement of the pinnules with respect to the rachis and the trunk may be had if an ordinary, expanded, young *Zamia* leaf is considered in its natural position on the summit of the trunk. If the pinnules of such a leaf are folded toward the axis of the trunk in two ranks, and these ranks are brought together side by side, the position of the parts in the unexpanded young leaf of *Cycadeoidea* will be paralleled. As just stated, it at once becomes apparent that the rachis is farthest away from the trunk, and that the upper side of each pinnule faces the axis of the trunk. This is also the relative position of the parts in the unexpanded young leaf of *Zamia*. *Cycadeoidea* thus had the direct mode of prefoliation characterizing the existing North American cycads *Zamia* and *Dioön*.

The Cycadeoidean Leaf Structure.

While an exhaustive treatment of the anatomy of these leaves must be deferred for the present, the features of more immediate interest may be here described.

The exact arrangement of the pinnules and of their fibro-vascular bundles is shown in the transverse section, figure 2 (Plate VII), and in the longitudinal section, figure 3, the general position of these sections being indicated in figure 1.

The transverse section, figure 2, shows that, just above the termination of the rachis, there are 20 pairs of projecting pinnules. Since the pinnules nearest the rachis must necessarily

be cut through their bases, while in a given transverse section those farthest from the rachis must be cut through their tips (as may be understood by referring to figure 1), this transverse section virtually represents a series of sections such as would be obtained if a single pinnule were cut transversely 20 times at regular intervals from base to tip. Nearer the base of the leaf, a transverse section cuts 34 pinnules. As there are about 20 insertions of pinnules above this basal section, and apparently no pinnules lying wholly beneath it, there are approximately 60 pinnules in all. The rachis and pinnular insertion have not yet been studied.

The principal fact of interest shown by the longitudinal section represented in figure 3 is the emergence of leaf tips on the side next the axis, or rachis, of the leaf. As this section is wholly above the termination of the rachis, this emergence indicates that the topmost pinnæ are relatively short. Necessarily, then, the leaf at this stage of its growth was of a somewhat truncate form.

This fact, however, does not permit surmise as to the exact leaf habit of *Cycadeoidea*, for subsequent growth either may have increased the truncation, or, because of great elongation of the rachis, resulted in a lanceolate leaf. Presumably the study of the prefoliation and subseqnent development of the rachis and pinnæ of living cycads, especially *Zamia*, will indicate what must have been the appearance of the full-grown leaf of *Cycadeoidea*.

The microscopic structure of the pinnules is partially shown in figures 4 and 5. In figure 4 is shown a transverse section through a pinnule cutting a fibro-vascular bundle. The structure of the relatively heavy epidermis of the upper side of the pinnule is not distinct even in this young stage, and forecasts a dense and stiff structure. A single layer of sclerenchyma cells of rounded section forms the hypodermis, from which a double row of similar cells passes in confluently to the bundle, where it divides to form a more or less complete circular row of sclerenchyma cells enclosing the phloem and xylem. The uniformity of this arrangement gives the transverse section of the bundles a characteristic flask-shape. Beneath the hypodermis is a distinct layer of palisade parenchyma followed by an indistinct one grading into the rounded parenchyma cells occupying the space between the bundles. The lower portion of the leaf, or that beyond the bundles, is composed of well-defined spongy parenchyma, with distinct intercellular spaces, and is bounded by a thin epidermis, the structure of which is not well marked. The lower surface at this stage is somewhat glabrous, although revolute margins are apparently indicated.

In figure 5 is shown a longitudinal section through the palisade parenchyma and bundle connection, with the hypodermis. This section displays clearly the usual dichotomous cycadean venation, as well as the mode of bundle increase. The pinnæ are of linear-lanceolate form, and without a distinct midrib.

A comparison of these structures with those of *Zamia integrifolia* shows a striking resemblance in all essential characters,—a resemblance that is even more marked than is that between the pinnæ of *Zamia* and of some of the other existing genera of the *Zamiaceæ* (*Zamiæ*).

The character of the ramentum surrounding these leaves remains to be briefly mentioned. It consists of thin scales, or hairlike forms, composed of stringy elements, and strongly resembles the ramental cells figured by Carruthers[3] and Seward[15] in their respective descriptions of *Bennettites Gibsonianus* and *Cycadeoidea gigantea*. A transverse section of the ramentum is shown in figure 6. The flat sides of these scales quite uniformly face the leaves, though as such a large portion of the summit is occupied by a mat of relatively the same character, it is probable that much of this hairy and scaly material is borne on the trunk in the space intervening between the petioles of the young leaves.

Yale Museum, New Haven, Conn., March 20, 1899.

EXPLANATION OF PLATE VII.

FIGURE 1.—Diagram of a hypothetical leaf, with a reduced number of pinnules, showing the position of the sections represented in figures 2 and 3. *O*, *O'*, are in the plane of the transverse section, figure 2, and also approximately mark the base of the longitudinal section, figure 3.

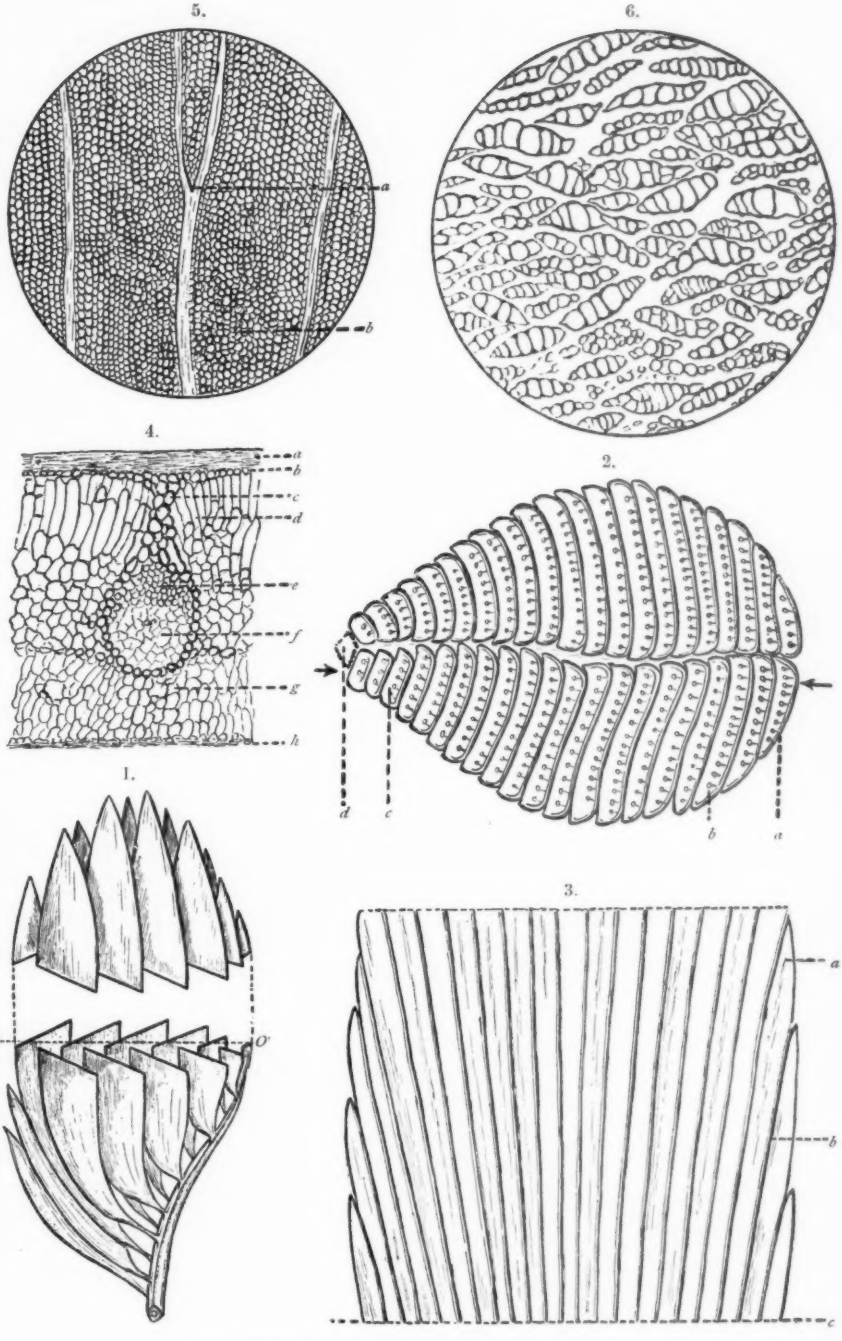
FIGURE 2.—*Cycadeoidea ingens*, Ward (type); transverse section through upper portion of young leaf. × 4. For relative position, see figure 1.
a, upper side of an inner pinnule cut near the summit; *b*, fibro-vascular bundle; *c*, pinnule cut near the base; *d*, axis of growth of rachis. The arrows indicate approximately the base line *O*, *O'*, figure 3.

FIGURE 3.—The same specimen; longitudinal section through summit of young leaf. × 4. For relative position, see figure 1.
a, summit of a pinnule near apex of leaf; *b*, upper side of pinnule; *c*, base line of section indicated in figure 1, *O*, *O'*.

FIGURE 4.—The same specimen; transverse section through a single pinnule, showing a fibro-vascular bundle. × 60.
a, upper side of leaf; *b*, hypodermis; *c*, sclerenchyma connection of hypodermis with fibro-vascular bundle; *d*, palisade parenchyma; *e*, xylem; *f*, phloem; *g*, spongy parenchyma; *h*, epidermis of under side of leaf.

FIGURE 5.—The same specimen; longitudinal section through a pinnule just beneath the hypodermis cutting the palisade parenchyma. × 35.
a, forking vein; *b*, palisade parenchyma.

FIGURE 6.—The same specimen; transverse section through the ramentum surrounding the young leaves. × 60.



CYCADEOIDEA INGENS, Ward (type); leaf structure

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On Luminous and Chemical Energy.*—The radical distinction which exists between photochemical reactions which are endothermic, in which light energy is converted into chemical energy, and those which are exothermic, in which the light is merely auxiliary, the greater portion of the change being effected by purely chemical agencies, has been recently emphasized by Berthelot, who has pointed out that it is only the former class of reactions which are adapted for use in the measurement of luminous energy. He has studied a number of substances when exposed to direct sunlight, to diffused daylight, or when kept in the dark, with reference to the changes thereby produced. The substances were contained in sealed tubes and the effect of different wave-lengths upon them was determined by surrounding them with colored media. Nitric acid when concentrated is decomposed by light at ordinary temperatures, and possibly at still lower temperatures, the reaction being similar to that which takes place in the dark at 100°, and which yields nitrogen peroxide, oxygen and water. The blue rays are most effective in producing the action, which is endothermic and not entirely reversible. The diluted acid is not affected by light, that of density 1·365 undergoing no change after weeks of exposure. The nitrogen peroxide formed tends to absorb those rays which are active in producing it. Iodic acid and oxide, while stable in diffused daylight, are decomposed by direct sunlight, setting free iodine and oxygen; the reaction being analogous to that produced by heat at 300°. It is limited by the absorptive action of the iodine vapor and by the deposition of iodine on the surface of the compound. Hence, while endothermic, this reaction is not suitable for the measurement of light energy. The action in the case of hydrogen iodide is on the line limiting endothermic and exothermic reactions, though the author's view is that a small amount of heat (0·4 calory) is evolved; though when solid iodine is set free, it is decidedly exothermic, 6·4 calories being evolved. The blue and violet rays are most effective, and the decomposition is most rapid in direct sunlight, there being an intermediate production of hydrogen periodide (HI_3?). Hydrogen bromide is not affected by the action of light even at 100°. Nor was any action observed with CO_2 either alone or mixed with hydrogen, with CO alone or mixed with hydrogen or oxygen, with SO_2 or HNO_3 when mixed with hydrogen. Red mercuric oxide is more rapidly decomposed than the yellow variety. Mercurous oxide when exposed to light yields traces of metallic mercury. No action was noticed with lead peroxide, silver oxide, or with mercuric chloride, bromide or iodide. Hence the author considers that the measurement of luminous energy by transformation into chemical

energy is to be effected by means of endothermic reactions which are irreversible at ordinary temperatures.—*C. R.*, cxxvii, 143–160, July, 1898. G. F. B.

2. *On the Homogeneity of Helium.*—By diffusion through a pipe stem, RAMSAY and TRAVERS separated a volume of helium first into six fractions. The first fraction was then pumped into the diffusion vessel, where one-half of it was diffused and transferred to vessel (1). Fraction No. 2 was then added and one-third of the mixture was diffused and transferred to vessel (1). Fraction No. 3 was then added and one-half of the whole diffused and transferred to vessel (2). Fraction No. 4 was then added and one-half diffused and transferred to vessel (3); and so on. Four complete fractionations of this sort in the case of air gave at the extreme fractions 17·37 and 22·03 per cent of oxygen respectively. When nitrogen was thus used, prepared from ammonium chloride and sodium nitrite, thirty fractionations produced no variation in density. In the case of helium, repeated fractionations of the gas from samarskite and cleveite gave a gas of density 1·98 and of refractivity 0·1238 as the lightest fraction and a very little pure argon as the heaviest one. Since further diffusion did not alter the density of the lighter fraction, the authors regard it as pure helium. "It appears therefore that helium contains no unknown gas nor is it possible to separate it by diffusion into any two kinds of gas; all that can be said is that most minerals which evolve helium also evolve argon in small quantity." The authors had hoped to find a gas with density 10 and atomic mass 20; since this would form with He = 4 and A = 40 a triad like that of F, Cl and Mn, 19 : 35·5 : 55. They still regard the existence of such an element as probable.—*Proc. Roy. Soc.*, lxii, 316–324, January, 1898. G. F. B.

3. *On the Properties of Ozone.*—By means of liquid air, LADENBURG has condensed ozonized oxygen to a liquid. Then by allowing this to evaporate partially, he has obtained a residue much richer in ozone, since this gas is less volatile than oxygen. So that by repeating the operation, he obtained finally a gas which contained 86·16 per cent of ozone and which had a density of 1·3698 as compared with oxygen, this density being determined from the rate of diffusion. Hence it follows that the density of pure ozone would be 1·456, theory assigning to it 1·5. He finds that ozone is not as soluble in water as has been supposed, 0·01 volume only being absorbed at the ordinary temperature and pressure, or 0·00002 part by weight. By condensing ozonized oxygen, allowing the oxygen to evaporate and then ascertaining the temperature at which the residual ozone evaporated, an attempt was made to determine the boiling point of ozone. The oxygen volatilized at —186°, leaving 4 or 5^{cc} of an almost black opaque liquid, the temperature of which then rose to —125°, at which point the liquid exploded. This temperature therefore can be taken only as a lower limit.—*Ber. Berl. Chem. Ges.*, xxxi, 2508–2515, October, 1898. G. F. B.

4. *On the Preparation of Alkali Nitrites.*—It has been pointed out by DIVERS that the common impression that in preparing alkali nitrites by passing nitrous fumes into alkali solutions, a method proposed by Fritsche in 1840, there is also produced much nitrate, is erroneous. The nitrous gases are made from nitric acid and starch or arsenous oxide, and are passed into the concentrated solution of the hydrate or carbonate until neutralization is effected; the vessel being loosely stoppered. The strength of the acid and the temperature are so regulated that the nitrogen monoxide is in excess of the dioxide. If the solution is acid, it must be boiled until neutral before exposing it to the air. Then the solution may be freely evaporated to crystallization. Both potassium and sodium nitrites are slightly yellow in color and are slightly alkaline. Sodium nitrite fuses at 271° and at 15° five parts of it requires six parts of water to dissolve it. It is moderately deliquescent, and its crystals are anhydrous. Potassium nitrite is very deliquescent, is soluble in about one-third its weight of water, and its crystals are reputed to contain half a molecule of water.—*J. Chem. Soc.*, lxxv, 85, January, 1899.

G. F. B.

5. *On the Composition of American Petroleum.*—By means of a combined dephlegmator and regulated temperature still-head, YOUNG has succeeded in preparing from American petroleum ether a number of nearly pure hydrocarbons. In some cases the fractional distillation was preceded by treatment with mixed nitric and sulphuric acids, in order to remove the benzene. Evidence of the presence of the following has been thus obtained: Isopentane B. P. 27·95°, normal pentane B. P. 36·3°, pentamethylene B. P. about 59°, isohexane B. P. about 61°, normal hexane B. P. 68·95°, methylpentamethylene B. P. about 72°, benzene B. P. 80·02°, hexamethylene B. P. 80·8°, isoheptane B. P. 90·3°, dimethylpentamethylene (?) B. P. about 94°, normal heptane B. P. 98·4°, methylhexamethylene B. P. about 102° and toluene B. P. 110·8°. These results show that the same classes of hydrocarbons, paraffins, polymethylene compounds or naphthenes and aromatic hydrocarbons are present in petroleum from all three sources, but that Russian petroleum contains a relatively larger amount of naphthenes and in all probability, of aromatic hydrocarbons than Galician, and Galician a larger amount of the same hydrocarbons than American petroleum.—*J. Chem. Soc.*, lxxiii, 905–920, December, 1898. G. F. B.

6. *Electrical waves along wires.*—A. SOMMERFELD has examined by means of elaborate mathematical analysis this subject, and has calculated the rate of damping and the decrease of velocity for the case of wires of different diameters. In the case of a copper wire 4^{mm} thick with a period of 10^9 per second, the electric wave velocity was 8 kilometers below the velocity of light. With a platinum wire of $\frac{4}{1000}^{mm}$ diameter, period $3 \cdot 10^6$ per second, the velocity falls to $\frac{3}{4}$ of the velocity of light. The ordinary experimental method, in which two parallel wires are used,

offers great mathematical difficulties. The author is apparently unacquainted with the direct experimental determination of the velocity of electric waves by Professor Trowbridge and Professor Duane, which avoids the mathematical difficulties, and by which a velocity closely agreeing with that of light was obtained.—*Wied. Ann.*, No. 2, 1899, pp. 233–290. J. T.

7. *Polarization and hysteresis in dielectrics.*—W. SCHAUFELBERGER employs ellipsoids of paraffine and hard rubber, and studies the damping of their oscillations in the electric field of a Kohlrausch condenser. The mathematical consideration of the motion of the dielectric contains hypotheses drawn from analogous phenomena of polarization and hysteresis in the case of iron. It was found that the loss of energy due to hysteresis in paraffine is 2·119 per cent and in hard rubber 63·49 per cent. The latter number is regarded as an approximation.—*Wied. Ann.*, No. 2, 1899, pp. 307–324. J. T.

8. *A new method of showing electric waves.*—A simple resonator devised by Rhigi consisted in a sheet of tinfoil applied to glass, the foil being divided by a fine line. ALBERT NEUGSCHWENDER has discovered that if a galvanometer and a battery are placed in circuit with a silver-coated surface divided by a fine line, that the galvanometer will show a deflection due to a Hertzian wave if one breathes on the metallic surface or places a wet sponge near it. The vapor converts the divided surface into a species of coherer.—*Wied. Ann.*, No. 2, 1899, pp. 430–432. J. T.

9. *Separation of long waves of heat by means of quartz prisms.*—The very important work of H. RUBENS and E. ASCHKINASS on this subject has shown that it is possible by means of quartz and sylvine to isolate waves of heat of great wave-length, since these waves are not absorbed by these substances. The above authors have now entered into a discussion of the further extension of their method. They find that intensity of energy between wave lengths 50μ and 60μ is greater than the whole energy beyond $\lambda = 60\mu$. Since the energy between 50 and 60μ is only $\frac{1}{100,000}$ of the whole amount of energy emitted by the sources employed by them (Auer burner), it does not appear possible to further extend their method.—*Wied. Ann.*, No. 2, 1899, pp. 459–466. J. T.

10. *Theory of conduction of electricity through gases by charged ions.*—Professor J. J. THOMSON has reduced his observations upon this subject to a mathematical form, and has obtained equations which embody his experimental results. He explains many of the phenomena observed in Geissler tubes, and believes that the most striking features of the discharge through vacuum tubes are due to the difference in velocity between the positive and negative ions. He points out that a study of the distribution of intensity in Geissler tubes supports the theory of ionization.—*Phil. Mag.*, March, 1899, pp. 253–268. J. T.

11. *The Hall phenomenon and the theory of Lorentz.*—POINCARÉ

has applied Lorentz's theory of electrical ions to the Hall phenomenon and has obtained an equation which represents the electromotive force obtained by Hall. He concludes that it would be desirable to examine whether all metals exhibit the Hall effect when they carry currents of very high electromotive force and whether a change of sign occurs.—*Comptes Rendus*, No. 6, Feb., 1899, pp. 339–341. J. T.

12. *On the Relation of the Surface Tension and Specific Gravity of certain Aqueous Solutions to their State of Ionization.*—Prof. MacGregor has shown that it is possible to calculate the various properties of solutions of potassium and sodium chloride in terms of the state of ionization of the electrolytes contained. The relation derived, in its simplest form, is $S = S_w + k(1-a)n + l\,a\,n$. where S is the numerical value of any property of a solution (density, surface tension, etc.), S_w that of the same property of water under the same physical conditions, n the number of equivalent gram-molecules per unit volume, a the ionization coefficient of the electrolyte in the solution, and l and k constants, called ionization constants, for any given property of any given electrolyte. Mr. E. H. Archbald has carried out a similar series of observations and calculations in the case of simple solutions of sodium, potassium and copper sulphates, salts of more complex molecular structure than those previously examined. He concludes that the expression given represents observed values of the surface tension and specific gravity of the solutions examined through a range of concentration extending from 0·05 to about 0·4 or 0·5 equivalent gram-molecules per liter. Further, that it is possible by aid of the dissociation theory of electrolysis to predict the surface tension and specific gravity of mixtures of potassium and sodium sulphate solutions and the specific gravity of mixtures of solutions of potassium and copper sulphates throughout nearly the same range, within the limits of the error of observation. And similarly, that it is possible to predict the specific gravity of mixtures of solutions of potassium sulphate and sodium chloride.

13. *On the Cause of the Absence of Coloration in certain Limpid Natural Waters.*—Professor W. Spring has an interesting article upon this subject in a recent number of the *Bibliothèque Universelle* (Jan. 15, 1899). Recognizing the accepted fact that pure water is distinctly *blue*, he remarks that the green color often observed is easily explained as due to the presence of more or less muddiness, which acts with the natural blue color to give a sensation of green. The absence of color, however, is a different problem, as early noted by Berzelius. The results of some experiments have led the author to the hypothesis that the suspension of minute, perhaps invisible, particles of anhydrous ferric oxide, or hematite, would have, through their red color, the effect of neutralizing the blue and leaving the water completely colorless. He notes the fact that microscopic grains of hematite are almost always found distributed in the soil, and that terrestrial waters have rarely the blue color which the pure liquid

fully illustrated in this report. Although it does not attempt to be an exhaustive paper on the statistics and engineering problems incident to developing the water supplies, the geology is presented in its relations to the occurrence of underground waters, their sources and relations to the beds carrying them. The paper not only presents an admirable exposition of geological structure, but must prove of great value in guiding the inhabitants of the region in supplying themselves with large supplies of fresh waters.

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should show. On the contrary, the water derived immediately from snow at high altitudes, or from glaciers, contains no hematite and is commonly intensely blue. The action of hydrated ferric oxide is different, since its color is yellow, and when present in very small amounts in the water, there is, so to speak, a struggle between it and the organic matter; if not overcome, the effect is to make the water appear green to the eye.

14. *A Text-Book of General Physics for the use of Colleges and Scientific Schools;* by CHARLES S. HASTINGS and FREDERICK E. BEACH; pp. viii, 768. Boston, 1899 (Ginn & Company).—The appearance of a new high grade text-book of physics is an event of much importance to all teachers and students in this department. The authors are to be congratulated upon the admirable manner in which they have treated the entire subject, particularly for their success in adequately presenting so vast a range of topics within the limits of a single moderate-sized volume. The work is characterized by the very careful and thorough treatment of the fundamental conceptions of the science; by the well-balanced relation between the different parts, no one portion of the subject being sacrificed to another; by the clear and precise mathematical development of each successive principle. At many points, moreover, though dealing with topics often treated of, there is much that is fresh and suggestive; this is particularly true of the chapters on Light.

The conciseness of expression and the mathematical, though elementary, method of presentation adopted have the advantage of brevity and accuracy, but they may leave much for the teacher to do if his pupils are approaching the subject for the first time. The student, however, who is properly prepared, will find no serious difficulty, and his subsequent work in special advanced fields will be much facilitated by the thorough grounding in principles and methods which he has here obtained.

Too much praise cannot be given to the publishers for the admirable form in which they have placed the work before the public. The page is clear and open, with no confused crowding of mathematical expressions, while the excellence of topography, illustrations and paper leaves nothing to be desired.

II. GEOLOGY AND MINERALOGY.

1. *New facts regarding Devonian Fishes. Dentition of Devonian Ptyctodontidea;* by C. R. EASTMAN; Am. Nat., vol. xxxii, pp. 473–488 and 545–560. July and August, 1898. *Some new points in Dinichthyid Osteology;* by C. R. EASTMAN; Am. Nat., vol. xxxii, pp. 747–768. October, 1898.—The first of these papers is the result of study of the rich material from the State Quarry fish-beds discovered by Prof. Calvin in the Devonian of Johnson County, Iowa (see Ann. Rept. Iowa Geol. Survey, vol. vii, 1897); private collections made by Mr. E. E. Teller and C. E. Monroe from the Hamilton limestone quarries of Milwaukee,

Wis.; and the Schultze collection in the Museum of Comparative Zoology containing European fish remains. The species described belong to the genera *Ptyctodus* Pander, *Rhynchodus* Newberry, *Palæomylus* Woodward, and ichthyodorulites are described under the new generic names *Phlyctænacanthus* and *Belemnacanthus*.

The stratigraphic relations of the fish remains and their association with invertebrate fossils lead the author to agree with the general conclusions of Stuart Weller regarding the relation of the Milwaukee beds to the New York and Iowa faunas.

"The Chimæroids give it (the hydraulic limestone of Milwaukee) a stamp of antiquity, suggesting that a westward migration took place during the early part of the Devonian as far as Wisconsin, but not crossing the Mississippi Valley until the Middle Devonian. The Milwaukee beds show the first traces of the encroachment from the East, the Rock Island locality a somewhat later, and the state quarry limestone the last of all, with its horde of Upper Devonian lung-fishes."

The second paper gives a critical comparative study of the cranial osteology of the Dinichthyids, with a particular description of an early type, *D. pustulosus* Eastman, based upon specimens from the Milwaukee and Iowa localities. The author considers this species to be the most primitive member of the genus known. His studies lead him to regard *Coccosteus* and *Titanichthys* as the extreme limits of the family Coccosteidæ, with *Dinichthys* as an intermediate and connecting link. Speaking of the *Dinichthyids* the author says: "But when their characters shall have been fully investigated, the wide range of variation manifested by them will be found reducible to order, and the whole promises to constitute one of the most interesting evolutionary series known among fossil fishes" (p. 747).

H. S. W.

2. *Geological Sketch of San Clemente Island;* by W. S. T. Smith. Extr., 18th Ann. Rept., U. S. Geol. Survey, 1896–97, Part II, pp. 459–496, plates lxxxiv–xcvi, figs. 82–85. 1898.—San Clemente is the southernmost island of the "channel islands" off the southern coast of California. The island has been described as a "tilted orographic block" by Lawson. The rocks are chiefly volcanic. The oldest sedimentaries are of Miocene age. The author recognizing this as a typical fault block, and isolated from other land masses, the topography of which is still in its infancy, has presented a theory as to the development of its drainage. He also describes the structural and petrographic features of the volcanics, and a general description of the sedimentaries, moraines and later deposits. H. S. W.

3. *Geology of the Edwards plateau and Rio Grande plain, etc.;* by Robert T. Hill and T. Wayland Vaughan. Extr., 18th Ann. Rept., U. S. Geol. Survey, 1896–7, Part II; pp. 193–321, plates xxi–lxiv, figs. 53–76. 1898.—The geological features of the region from Austin, Texas, westerly and southwesterly through San Antonio to the Rio Grande, are described and beauti-

fully illustrated in this report. Although it does not attempt to be an exhaustive paper on the statistics and engineering problems incident to developing the water supplies, the geology is presented in its relations to the occurrence of underground waters, their sources and relations to the beds carrying them. The paper not only presents an admirable exposition of geological structure, but must prove of great value in guiding the inhabitants of the region in supplying themselves with large supplies of fresh waters.

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the members of all geographical societies and cognate scientific bodies or institutes, to assemble at the German capital, Berlin, for the meeting of the seventh International Geographical Congress, to be held from Sept. 28th to Oct. 4th, 1899. Membership tickets may be obtained by gentlemen or ladies by payment of 20 marks to the Treasurer, H. Bütow, 90 Zimmerstrasse, Berlin S. W. All wishing to read papers before the Congress are requested to give notification thereof before April 1st, 1899, and to send the manuscript ready for print not later than June 1st, 1899.

H. S. W.

8. *Funafuti.*—The January number of *Natural Science* contains an interesting and popular discussion of the life and geological features of Funafuti as a typical coral atoll, by W. J. Sollas. Special interest attaches to this island in consequence of the work which has been done here in boring into the coral rock. The party sent out from England, which was directed by Professor Sollas, unfortunately did not succeed in carrying the boring to any considerable depth. The work, however, was continued in 1897 under the direction of Professor David of the University of Sydney, and this time was entirely successful, the reef being penetrated to a depth of 697 feet. Later, a third party was sent from Sydney, which has carried the boring on to a depth of about 1000 feet. The core obtained by the David party was sent to England and is now in the hands of Professor Judd for investigation, the results of which will be awaited with much interest. The general statement is made, however, that the material brought up from the boring, of which the reef is composed, presents much the same character throughout, and so far is regarded as supporting Darwin's theory. There are no layers of chalky ooze, such as Murray's hypothesis might have made probable, and no trace of volcanic material was found. The later boring beyond 700 feet has passed through a hard limestone, containing many well-preserved corals. The last mentioned expedition has also carried on a boring into the bed of the lagoon to a depth of 144 feet. After passing through 101 feet of water, the first 80 feet below were found to consist of the calcareous alga Halimeda, mixed with shells; the remaining 64 feet, of the same material mixed with coral gravel.

9. *Petrographical and Geological Investigations of certain Transvaal Norites, Gabbros, and Pyroxenites;* by J. A. Leo Henderson (8° pamph., 56 pp., 5 pl., Dulau & Co., Pub., London, 1898).—Although this appears as a separate work, one is led to infer that it is a thesis presented for the doctor's degree at Leipzig. The material upon which the investigations have been carried is from the Stelzner collection at Freiberg and was gathered by the explorers Mohr and Goerz. As may be inferred, therefore, it is a minute and painstaking petrographical and chemical investigation of a series of hand specimens determined as diallage norite, hypersthene norite, hypersthene diallage gabbro, quartz norite, quartz diallage norite and enstatite pyroxenite.

In addition some gneisses and other rocks are described. Among them is a syenite and syenite porphyry which are shown to have anorthoclase (soda microcline) as the feldspar, and the author believes this to be a sufficient ground for the erection of a new rock group and proposes the names of *hatherlite* and *pilandite* for them respectively. Probably the majority of petrographers will hardly agree to this, since as commonly understood the syenite family is one composed essentially of alkaline feldspars in general and not one particular variety of them. As a matter of fact, the pure potash feldspar is of very rare occurrence as a rock-ingredient and the great majority of the so-called orthoclases contain the albite molecule to a greater or less extent. Moreover since the analyses of the feldspars of the rocks mentioned show that they contain a very considerable quantity of lime, it appears questionable whether they should not be classed as abnormal oligoclases rather than anorthoclase (soda microcline); they are clearly not typical examples of the latter.

Very full and painstaking investigations have been made in this work of the augitic constituents of the rocks mentioned which have been separated and analyzed, but it seems rather curious from modern standpoints that with so much chemical investigation of the constituents no mass analyses of the rocks except in one case have been made. This is a rock consisting of enstatite crystals including 4·5 per cent of anorthite plates. The analysis gave:

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	H_2O	Sp. G.=3·3
55·23	0·44	2·08	3·94	6·25	29·29	1·68	1·12	= 100·03

It is an enstatite pyroxenite from the Central Marico District.

L. V. P.

10. *On the Occurrence of Corundum.*—Two recent papers on the occurrence of corundum in widely separated parts of the world deserve to be mentioned. One of these, by T. H. Holland,* discusses in detail the various corundum localities, including the gem varieties, ruby and sapphire, in India and the adjacent countries. The second paper, by W. G. Miller,† describes the corundum and associated minerals of Eastern Ontario.

The most interesting point brought out in both papers is the fact that corundum occurs so often associated with igneous rocks; this fact has also been recently established in other regions. Mr. Holland accepts the fact that in certain cases it may have a secondary origin, as shown by Professor Judd for the ruby, but for the most part he regards it as an original constituent, though often due to the local excess of alumina. The Indian localities are divided into those in which the corundum occurs with basic rocks and these in which its associates are siliceous, that is, *acid.* In the former class pyroxene is the predominating constituent,

* A Manual of the Geology of India: Economic Geology by the late Professor V. Ball. Second edition revised in parts. Part I, Corundum, by T. H. Holland; pp. 79, Calcutta, 1898.

† Report of the Bureau of Mines, vol. vii, third part, pp. 207–265, Toronto, 1898.

together with some member of the spinel group. These occurrences are divided into three groups. In the first, the *ferruginous* group, the pyroxene is a highly ferriferous enstatite and the spinel either hercynite, or hercynite with magnetite; in this group ilmenite may largely replace the corundum. In the second, the *ferro-magnesian* group, ferrous oxide is largely replaced by magnesia, a less ferriferous enstatite and pleonaste, also sometimes chrysolite, being the type minerals. In the third, or *magnesian* group, iron compounds occur in very small quantity, the associated minerals being magnesian forms of chrysolite, also (secondary) talc, dolomite, magnesite.

In the second class, the corundum is associated with *acid* rocks. This is well illustrated by the sapphire of Kashmir, which occurs in granite; here the granite (pegmatite) forms veins in gneiss and carries with the sapphire, tourmaline, euclase, cyanite, etc.; green tourmaline, spodumene, cookeite and prehnite are also found. The gneiss is coarse and schistose, with white feldspar, black mica and also garnets.

The corundum of Ontario, as described by Mr. Miller, belongs chiefly to dikes of syenite and quartz pegmatite intersecting the Laurentian gneiss. It is found more abundantly in ordinary syenite than in nepheline syenite, but in the latter the crystals are better formed. It is also found in eastern Ontario in crystalline limestone, as in Burma, where it is regarded as of secondary origin. Mr. Miller's paper is accompanied by numerous interesting plates illustrating the actual occurrence of the mineral. Other mineralogical points are also brought out, as the occurrence of nickel-bearing magnetite, also of a mineral of the columbite type (G.=5·40), in Renfrew County.

11. *Minerals in Rock Sections:* The practical methods of identifying minerals in rock sections with the microscope. Especially arranged for students in technical and scientific schools. By Lea McIlvaine Luquer; pp. 117. New York, 1898 (D. Van Nostrand Company).—This subject has been already treated of by a number of authors, but there still remains place for the present volume. It gives in the opening chapters a concise summary of the optical principles, methods and instruments, and following a statement of the characters of minerals arranged with system and clearness. A chapter is also added on the methods of making sections and one on chemical tests. An optical scheme is added in the appendix.

12. *New Mineral Names.*—Lagoriolite. In connection with his important work in mineral synthesis and the crystallization of minerals from a molten magma, Morozewicz has obtained isometric crystals or crystalline grains of a mineral having the composition $(Na_2Ca)_3Al_2(SiO_4)_3$, in which $Na_2 : Ca = 3 : 2$. This corresponds to a sodium-grossularite, a type of garnet not yet noted in nature but which has peculiar interest as connecting the garnets with the minerals of the Sodalite Group. This compound is named after Prof. A. Lagorio.—*Min. petr. Mitth.*, xviii, 147, 1898.

THALENITE. A new yttrium silicate, having the composition $H_2Y_4Si_4O_{15}$. It occurs in tabular monoclinic crystals of a flesh-red color. Hardness = 6·5; specific gravity = 4·229. Found in Österby in Dalecarlia, Sweden, and named by Benedicks after Prof. R. Thalén.—*G. För. Förh.*, xx, 308, 1898.

KTYPEITE. A name given by Lacroix to the calcium carbonate in the form of pisolites from Carlsbad and Hammam-Meskoutine in Algeria, which has formerly been referred to aragonite. The specific gravity varies from 2·58 to 2·70, or less than that of calcite. Optically the birefringence is 0·020. In parallel polarized light a distorted black cross is noted, while portions give a positive black cross in converging light. Heated to low redness, the pisolites decrepitate and are finally transformed into calcite; the name given refers to this fact.—*Comptes Rendus*, cxxvi, 602, 1898.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *The Benjamin Apthorp Gould Fund.*—A circular has recently been issued by the Directors of the Gould Fund, Professors Lewis Boss, Seth C. Chandler and Asaph Hall, stating that a sufficient available income has now accrued to warrant beginning its distribution, and that they are prepared to receive and consider applications for appropriations. It will be remembered that the fund was established in November, 1897, when the sum of twenty thousand dollars was given to the National Academy of Sciences, as trustee, in memory of the father of the donor, Miss Alice Bache Gould, the income to be used to assist the prosecution of researches in astronomy.

In order to guide those desiring to secure appropriations from the fund, the directors make the following statement:

The objects of the institution are, first, to advance the science of Astronomy; secondly, to honor the memory of Dr. Gould by ensuring that his power to accomplish scientific work shall not end with his death. In recognition of the fact that during Dr. Gould's lifetime his patriotic feeling and ambition to promote the progress of his chosen science were closely associated, it is preferred that the fund should be used primarily for the benefit of investigators in his own country or of his own nationality. But it is further recognized both by the donor and the directors that sometimes the best possible service to American science is the maintenance of close communion between the scientific men of Europe and of America, and that, therefore, even while acting in the spirit of the above restriction, it may occasionally be best to apply the money to the aid of a foreign investigator working abroad. The wish was also expressed by the donor that in all cases work in the astronomy of precision should be given the preference over any work in astrophysics, both because of Dr. Gould's especial predilection and because of the present existence of generous endowments for astrophysics.

Finally, the Benjamin Apthorp Gould Fund is intended for the

advancement and not for the diffusion of scientific knowledge, and is to be used to defray the actual expenses of investigation, rather than for the personal support of the investigator during the time of his researches, without absolutely excluding the latter use under the most exceptional circumstances.

Application for appropriations from the income of this fund may be made informally by letter to any of the directors, stating the amount desired, the nature of the proposed investigation, and the manner in which the appropriation is to be expended. If favorably considered, a blank for formal application will be forwarded for signature, with the rules adopted by the directors for the administration of the fund, and to which the applicant will be expected to subscribe.

2. *Annual Report of the Board of Regents of the Smithsonian Institution for the year ending June 30, 1896. Report of the U. S. National Museum;* pp. xxiv, 1107. Washington, 1898.—The Report of the United States National Museum for the year ending June 30th, 1896, has recently been issued. It includes the report of the Assistant Secretary, the late Dr. G. Brown Goode, which gives, in addition to matters of current interest, an outline of the history of the Museum, showing how it has grown to its present dimensions. A series of Appendices relating to Museum matters follow.

Part II of the volume, covering nearly 750 pages, includes a paper entitled: An account of the United States National Museum by Frederick W. True (reprinted); also a series of ethnographical papers elaborately illustrated with many text figures and full page plates. The first of these, by Thomas Wilson, discusses the origin of art as manifested in the works of pre-historic man; those not acquainted with the subject will be surprised to see what a variety of objects is here described and illustrated and how great interest attaches to them. The other articles are on Chess and Playing Cards by Stewart Culin; Biblical Antiquities by Cyrus Adler and I. M. Casanowicz; The Lamps of the Eskimo by Walter Hough.

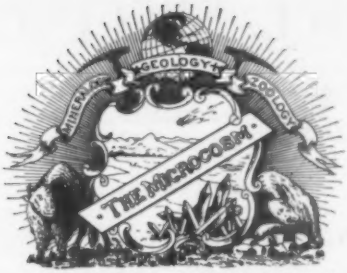
3. *The Second Washington Catalogue of Stars: together with the Annual Results upon which it is based.* The whole derived from Observations made at the U. S. Naval Observatory with an 8·5 inch transit circle, during the years 1866 to 1891, and reduced to the epoch of 1875·0. Prepared under the direction of JOHN R. EASTMAN, Professor of Mathematics, U. S. N., Washington Observations for 1892, Appendix I, pp. lxiii, 287, Washington, 1898.—This large volume of star observations, as stated in the preface by the Director of the Observatory, Professor Harkness, has absorbed the labors of about two-thirds of the Observatory staff for more than thirty years, during the greater part of which time Professor Eastman was in immediate charge. His personal work included 17,334 observations of stars, out of nearly 73,000; and nearly 40,000 were made under his immediate direction. Professor Harkness adds that the credit and responsibility for the methods of discuss-

ing the observations, for the values of the systematic corrections applied in the formation of the final places, and for the arrangement of the volume rest with Professor Eastman.

4. *Zoological Results based on material from New Britain, New Guinea, Loyalty Island and elsewhere, collected during the years 1895–1897;* by ARTHUR WILLEY, Cambridge, England, Part II, pp. 121–206, plates xii to xxiii.—The first part of this important series of memoirs was noticed in the January number of this Journal (p. 79). The present part contains the following seven papers: 7, Report on the specimens of the genus *Millepora*, by S. J. Hickson, pl. xii–xvi; 8, On the Echinoderms (other than the Holothurians) by F. Jeffrey Bell, pl. xvii; 9, Holothurians, by F. P. Bedford, pl. xviii; 10, On the Sipunculoidea, by A. E. Shipley, pl. xviii; 11, On the Solitary Corals, and 12, On the postembryonic development of *Cycloseris*, by J. Stanley Gardiner, pl. xix, xx; 13, On a collection of Earthworms, by F. E. Beddard, pl. xxi; 14, On Gorgonacea, by Isa L. Hiles, pl. xxii, xxiii. Part III is stated to be now in press.

5. *A Select Bibliography of Chemistry, 1492–1897;* by HENRY CARRINGTON BOLTON. First Supplement; pp. ix, 489. Washington, 1899. (Smithsonian Miscellaneous Contributions, 1170.)—Workers in science owe much to the careful and painstaking labors of those who prepare the bibliographies in the different departments. One of the most complete of these is the Bibliography of Chemistry, 1492–1892, by Professor Bolton, which was issued in 1893. A First Supplement to this work has now been issued, bringing the literature of the subject down to the close of 1897. This is a closely printed volume of nearly five hundred pages, which fact alone gives evidence of the large amount of material brought together. The total number of titles is 5554 in twenty-five different languages; these titles are classified under the following seven heads: Bibliography; Dictionaries and Tables; History of Chemistry; Biography; Chemistry, Pure and Applied; Periodicals.

6. *Biological Laboratory.*—The Biological Laboratory of the Brooklyn Institute of Arts and Sciences will be located for its tenth season at Cold Spring Harbor, Long Island, during the months of July and August, 1899. The director of the laboratory is Charles B. Davenport, Ph.D. of Harvard University. A circular giving the names of instructors, courses of study offered, equipment and other details has recently been issued, and copies may be obtained from Prof. F. W. Hooper, 502 Fulton st., Brooklyn.



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(1) Described in this Journal Sept., 1895. (2) Ibid Nov., 1887. (3) Proc. Roch. Acad. Sci. Vol. 1. (4) This Journal Aug., 1888. (5) Ibid July, 1893. (6) Ibid June, 1894. (7) Ibid Nov., 1892.

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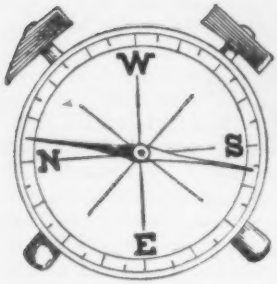

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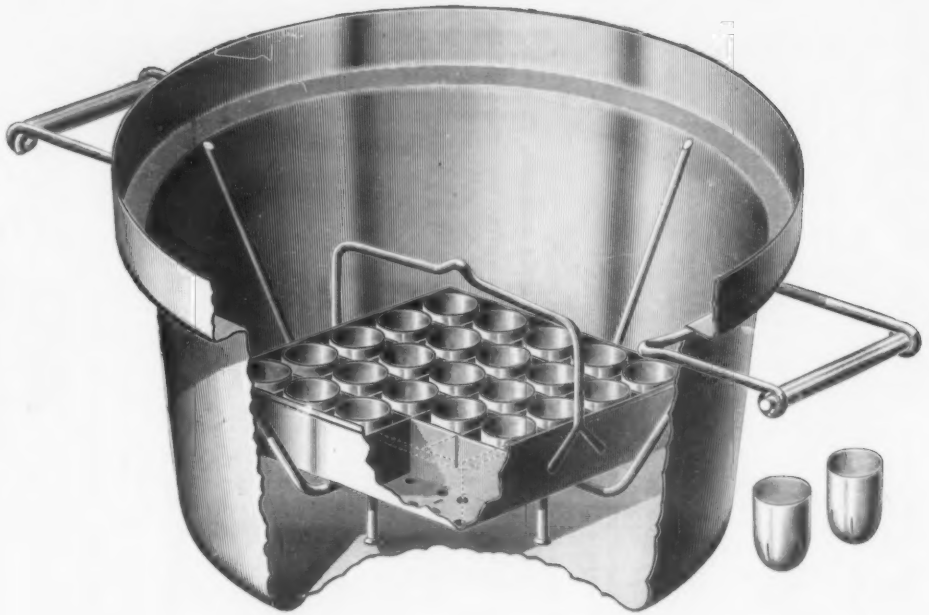

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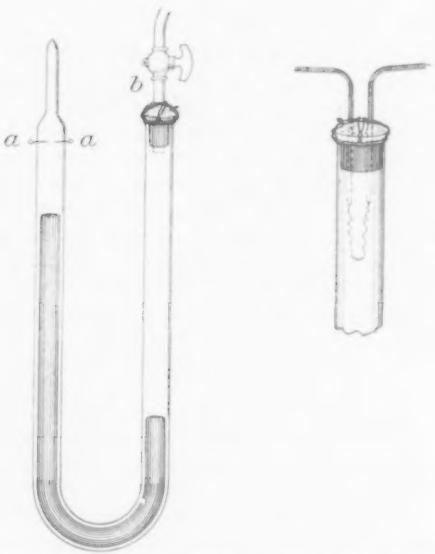
[FOURTH SERIES.]

ART. XXXIV.—*On some Experiments with Endothermic Gases;* by W. G. MIXTER.

[Contributions from the Sheffield Laboratory of Yale University.]

THESE experiments were made in U-tubes of 30 to 50^{cm} in length and for high pressures the form shown in fig. 1 was

1. 2.



employed. The part above the electrodes *a a* was narrowed for convenience in opening the tube and measuring small residual quantities of gases. The other end was connected by means of a small copper tube with a hydraulic pump. At *b*

was a thick wrapping of cotton wicking to protect the rubber stopper from the wire used to hold it in place. Such a connection answered for a pressure of 20 atmospheres by the pump and withstood explosions that burst the other limb of the U-tube. For filling the apparatus a little mercury was poured in to form a trap at the bend and the air was displaced by passing in a liter or more of gas through a small rubber tube reaching to the closed end; then more mercury was added, the stopper adjusted, the apparatus placed in a tall glass jar to prevent danger from flying glass and to catch the mercury in case the tube broke. The desired pressure was obtained by forcing in water with a pump. For pressures of three atmospheres or less a reservoir of mercury connected by means of a rubber tube was convenient, the heighth of the mercury in the reservoir above its surface in the U-tube being the measure of the pressure. For heating gases by a glowing wire the end with the electrodes in fig. 1 was modified as indicated in fig. 2. To the heavy copper wires passing through the rubber stopper was soldered a platinum wire which was made to glow or even melt by a battery current.

Acetylene.

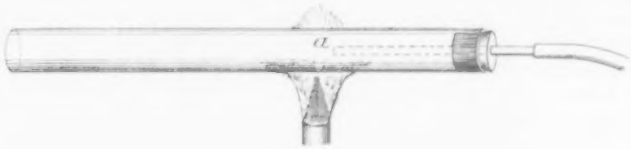
Berthellot and Vieille* have investigated the explosion of acetylene, and hence it is only necessary to state that my results, obtained before their paper was published, accord with theirs and that they are briefly given in order to show that the other endothermic gases tested do not explode in the same apparatus and under the same conditions. At a pressure of two atmospheres when an electric spark was passed or a platinum wire was made to glow in the gas it sometimes did not explode, while at a pressure of three or more atmospheres explosions always occurred. If, however, the sparks are small acetylene does not explode even at high pressures. A number of tests were made in a tube shown in part in fig. 3, containing acetylene under various pressures up to 20 atmospheres; when the inner and outer wires were connected with an induction coil in action, sparks visible in strong daylight passed between the glass and the inner wire. This form of discharge did not cause explosion. When it continued for some time a reddish deposit appeared. This was insoluble in ordinary solvents, and exploded when heated, leaving a black residue. It was not further investigated. The presence

3.

* Compt. Rend., cxxiii, 523.

of an indifferent gas checks the explosion of acetylene, as the following show: A dry mixture of 1 volume of acetylene and 2 volumes of hydrogen at a pressure of 5 atmospheres was not exploded by sparking; carbon separated slowly but there was no cloud of soot. The result was the same with equal volumes of the two gases at 6 atmospheres, while with a mixture of 2 of acetylene and 1 volume of hydrogen at 5 atmospheres, the explosion promptly followed the electric discharge. The spark used was 2^{cm} in air and was passed between electrodes 3^{mm} apart in the gas.

4.



The following experiment illustrates beautifully and simply the endothermic character of acetylene and also shows that a dull red heat is sufficient to decompose it. A slow current of the gas is passed through the tube *a*, fig. 4, into the larger tube, which is heated as shown by a Bunsen burner. When the part of the outer tube about the end of *a* is heated to a faint glow there is a slight puff and then the gas issuing from the end of *a* glows or rather the carbon, separating beyond the end of the little tube, glows. It is a jet of gas filled with a cloud of lampblack glowing with the heat resulting from the dissociation of the acetylene. In order to obtain the result the flow of the gas must be carefully regulated. If too fast, the gas does not attain the temperature of decomposition, and if too slow it does not glow.

Cyanogen.

Experiment 1.—The U-tube, fig. 1, was charged with cyanogen made from dry mercuric cyanide. The gas was nearly free from air or other permanent gases, as it was found that 100^{cc} left only a small volume of gas when liquefied by pressure. When induction sparks were passed through the vapor of cyanogen at a pressure of about five atmospheres, at which a portion of the compound was liquid, carbon separated at once and connected the electrodes. There was no explosion and no decomposition except in the path of the spark. A primary current from two large storage cells was next passed, the carbon filament connecting the platinum wires in the tube

serving as a conductor. The result was a brilliant violet light and the separation of a little more carbon. The primary current had, however, broken the filament so that on connecting again with a coil in action sparks passed, but soon ceased. The primary current then gave the same result as before. The amount of cyanogen decomposed was small, for of the 100^{cc} taken only 1^{cc} was not absorbed by potassium hydroxide after the experiment.

Experiment 2.—Cyanogen was condensed in the apparatus fig. 2 until a portion liquefied, and the wire was heated white hot by a current from a battery. A slight fog appeared but there was no separation of carbon throughout the gas, and there was no explosion. The result was the same at lower pressures. Finally the platinum wire was melted in the gas at the pressure of liquefaction, but there was no explosion nor any considerable decomposition. A thin coating of carbon had formed on the wire.

Nitrous Oxide.

Experiment 1.—The apparatus, fig. 1, was filled with 72^{cc} of pure dry nitrous oxide, and the gas was condensed to 6^{cc} and sparked. There was no explosion. Faint red fumes appeared. On lowering the pressure after the sparking to that of the atmosphere, the gas showed increased volume but not 50 per cent, as would have been the case had the dissociation been complete.

Experiment 2.—100^{cc} of gas condensed to 5^{cc} and finally to 3^{cc} were sparked for some time. There was no explosion and the volume at the close of the experiment was less than 150^{cc}.

Experiment 3.—70^{cc} of nitrous oxide were condensed to 5^{cc} and sparked. The result was the same as in the preceding experiments.

Experiment 4.—100^{cc} of nitrous oxide condensed to 10^{cc} were sparked. There was no explosion.

In the above tests the platinum electrodes were 4^{mm} apart and the spark used was fairly strong and had a length in air of 3^{cm}.

Nitric Oxide.

Experiment 1.—Dry nitric oxide was sparked at pressures varying from 12 to 20 atmospheres. There was no explosion, but the gas became reddish.

Experiment 2.—100^{cc} of dry nitric oxide were condensed to 10^{cc}. The spark and electrodes were as described under nitrous oxide. The first spark through the gas produced a small flame between the electrodes. The sparking was continued only a

few seconds. The gas remaining was nearly all absorbed by a solution of ferrous sulphate, showing that only a small portion of the nitric oxide had been decomposed.

Experiment 3.—50^{cc} of gas were condensed to 6^{cc} and sparked a short time. After treatment with ferrous sulphate only 0·5^{cc} remained.

The deportment of nitrous and nitric oxide in the above tests is much the same as in the well known experiments of sparking these gases at ordinary pressure.

The results of the experiments described in this article will be discussed in the next paper.

ART. XXXV.—*On a Hypothesis to explain the partial non-explosive Combination of Explosive Gases and Gaseous Mixtures;* by W. G. MIXTER.

[Contributions from the Sheffield Laboratory of Yale University.]

MUCH has been done in investigations of the conditions under which gases combine gradually or with explosive violence. The velocity of explosive waves has been determined, and the influences of pressure, and of excess of one gas or dilution with an indifferent one, have been studied. Dixon* states, "The explosive wave is propagated not only by burnt molecules, but also by those of the heated but yet unburnt molecules." But so far as the writer is aware, no hypothesis has been advanced to account for the fact that explosive mixtures will not explode at low pressures, and that weak electric sparks may not cause explosions, where strong sparks do. Victor Meyer, with the aid of his pupils, has made a large number of experiments with explosive mixtures at different temperatures and pressures, but he has offered no explanation of the phenomenon of slow combination in such mixtures. As the union of hydrogen and oxygen has been more thoroughly studied than that of other gases, the deportment of detonating gas, by which is understood equivalent amounts of hydrogen and oxygen, under various conditions, affords the best basis for discussion. The behavior of certain other gases, and the observations of different experimenters, will also be considered.

Dixon† found that detonating gas at a pressure of 70^{mm} does not explode when an electric spark is passed through it, and

* Chem. News, lxvii, 39. † Trans. Roy. Soc., 1884, 634.

L. Meyer and Seubert* observed at the same pressure that three-fourths of the gas combined. The writer noticed† that weak sparks did not cause an explosion of the gas. This is not peculiar to detonating gas, as Dixon‡ states that "The explosion of cyanogen and oxygen depends solely on the nature of the spark. A strong spark causes the mixture to explode violently, whether wet or dry. A weak spark may be passed through the mixture, wet or dry, without apparent effect."

Emich§ has recently studied the inflammability of thin layers of explosive mixtures of gases, and has found that the length of the spark required for ignition bears an inverse relation to the density, and that the addition of oxygen to detonating gas till it is to the hydrogen as 1 : 1 increased the sensitiveness of the mixture to sparks; an analogous fact obtains for an explosive mixture of hydrogen and chlorine. On the contrary, equivalent mixtures of carbonic oxide and oxygen are more sensitive than those containing an excess of either.

The glow discharge of electricity produces gradual combination of explosive mixtures.‖ Meyer and Raum¶ experimented with detonating gas in sealed bulbs, and observed no perceptible combination after exposure for 218 days, to a temperature of 100°, while after 65 days, at 300°, they found in three tests that 9·5, 0·4, and 1·3 per cent of the gas had united. They obtained at 350° and 50 hours, 1·6 per cent, and after 120 hours, 1·9, 16·4, 0·5, 0·7 per cent. Krause and Meyer** found that 28 to 100 per cent of detonating gas combined when heated to 518° for 2 hours, in sealed bulbs. On the other hand, Askenasy and Meyer†† observed that but little water was formed where the gas passed slowly through a vessel at 606°. Freyer and Meyer‡‡ determined the temperatures at which mixtures of gases exploded when slowly passing through a hot vessel, and also when quickly heated in sealed bulbs. Explosions occurred at the higher temperatures given in the following table, but not at the lower:

		With free current.	In sealed bulbs.
Hydrogen	with oxygen required for complete combustion	650–730°	518–606°
Methane		650–730°	606–650°
Ethane		606–650°	518–606°
Ethylene		606–650°	518–606°
Carbonic oxide		650–730°	650–730°
Hydrogen sulphide		315–320°	250–270°
Hydrogen and Chlorine		430–440°	240–270°

* Jour. Chem. Soc., xlv, 587.
† This Journal, iv. 51.
‡ J. Chem. Soc., xlix, 384.
§ Monatsheft f. Chem., xviii, 6, xix, 299.
‖ This Journal, iv, 51, 1897.
¶ Ber. d. deutsch. Gesell., xxviii, 2804.
** Liebig's Ann., cclxiv, 85
†† Liebig's Ann., cclxix, 49.
‡‡ Zeitschr. für phys. Chem., xi, 28.

They also found that detonating gas suddenly heated in unsealed bulbs exploded at the same temperature as in sealed.

Before discussing chemical changes let us recall the condition of matter in gases—the molecules are moving very rapidly, some faster, some slower, an individual molecule moving in a straight line for a very short distance, until it strikes another. These collisions of one molecule with others are very frequent. The atoms composing a molecule are also moving in respect to each other, this motion constituting a portion of the internal energy of the molecules, which is continually diminishing through radiation. When the gas is heated the mean velocity of the molecules is increased, and at the same time the atomic motion and internal energy are also increased. At a sufficiently high temperature some of the collisions are so violent as to disrupt the molecules and their atoms part company.

When a mixture of gases is heated, chemical combination results from the encounters of different kinds of molecules having motion of translation, or of the atoms, or of both. At any given temperature the mean velocity of molecules may be calculated, but we have no data for determining at what greater velocity the molecular collisions are followed by chemical union. Polyatomic molecules are dissociated by heat, but since there is no measurable dissociation of hydrogen or oxygen at 1600° it does not appear that dissociation by heat plays much part in the change. Whatever the chemical changes caused by heat in gases, whether combination or dissociation, the condition necessary for these changes results from molecular impacts. If, for example, detonating gas be heated, a part of the molecules acquire a velocity and internal energy adequate for combination. Some of these encounter each other and combine to form water, the free atoms of oxygen uniting with each other or with hydrogen. The nascent water molecules have in general a high velocity, and collide with those of oxygen and hydrogen; but it is not probable that a single impact of a new water molecule with one of hydrogen or oxygen imparts to the latter energy adequate for combination. If it were so, the change would proceed with accelerating speed at a temperature of 300° to 500°. This view, that a nascent water molecule does not necessarily cause hydrogen and oxygen to unite, accords with that expressed by the writer,* that the heat of combination caused by the glow discharge of electricity does not produce further combination.

Why is it that chemical union proceeds slowly at 500°, and why does not the energy resulting from combination cause further combination, and thus raise the temperature of the sys-

* This Journal, vi, 218, 1898.

tem to the point of explosion? Let us suppose the mixed gases be heated from 500° to 501°. This increase in temperature will not cause them to explode. Assume further, that the heat of combustion during one minute is sufficient to raise the temperature of the gases 1°, provided no heat is lost by radiation. Experiments have shown that this rise in temperature will not cause explosion. But the gases heated by their own slow combustion continually lose heat by radiation, and hence are only slightly hotter than the surrounding medium. Were it possible to prevent loss of heat, the temperature would rise and the change proceed with accelerating speed.

The observations of Freyer and Meyer (loc. cit.), that explosive mixtures gradually heated have a higher ignition point than when suddenly heated, are difficult to explain, and further experiments may be useful. Their results also indicate that pressure is without influence, while A. Mitscherlich* found that at pressures less than one atmosphere the ignition point falls with the pressure. As pressure in so many cases influences explosion, it is remarkable in Freyer and Meyer's experiments that detonating gas in an open vessel, when quickly heated, exploded at the same temperature as it did under a pressure of two atmospheres or more. Mitscherlich's results also are the opposite of what we might expect.

Let us first consider the phenomenon of explosion of detonating gas at a low pressure when the combination is not complete. An electric spark or hot wire ignites the gas, the water molecules about the source of heat collide with the neighboring ones of hydrogen and oxygen, molecules of these elements being shaken up by many impacts and acquiring energy adequate for combination, and thus uniting and adding energy to the system. In this way the change propagates itself. A part of the molecules of hydrogen and oxygen have not combined. Why? When a denser gas is ignited, the combination is complete, and as the temperature of burning hydrogen is sufficient to dissociate water, we must assume that some of the water molecules are broken up, and as the temperature falls they reform, all of the hydrogen and oxygen uniting before the temperature is too low for combination. In the case of the rarer gas, the impacts to which a molecule of hydrogen or oxygen is subject from the nascent water molecules are less frequent than in the denser gas, and hence it is not as likely to acquire the energy needed for chemical union. Moreover, molecules possessing velocities adequate for combination encounter each other less frequently in the rare gas; hence the chemical change will proceed more slowly, and there will be more time for the system to lose heat by radiation. A

* Ber. d. deutsch. Chem. Gesell., xxvi, 399.

molecule with internal energy adequate for combination loses this energy if its free path is relatively long; that is, given sufficient time though very brief, the molecule assumes a condition unfavorable to chemical union.

Let us now see if other phenomena are explained by this hypothesis, considering first the case of an electric spark in detonating gas at a pressure too low for explosion. Here we have an enormous number of molecules combining in the luminous path of the spark. These radiate energy, part being electrical in its origin, i. e., a portion which was derived from the external work done upon the gas, and part resulting from chemical union. These encounter neighboring molecules of hydrogen and oxygen, imparting to some of them energy adequate for combination. Of these last a part combine, and we have now to consider a portion of gas consisting of water molecules, as well as those of hydrogen and oxygen. Some of the last named possess energy adequate for chemical union, but their encounters are too infrequent to restore by the heat of combination the energy radiated, hence the change proceeds with diminishing speed and finally ceases to propagate itself.

Feeble sparks do not explode detonating gas at a pressure of half an atmosphere or even more, but they cause slow combination. In this case it is not necessary to consider the possibility of the hydrogen carrying the electricity, since water molecules are formed, and we need only take into account a system made up of a relatively small number of nascent molecules of water, molecules of hydrogen and oxygen having energy adequate for combination, together with a relatively large number of molecules of these gases not having such energy. Under these conditions the impacts resulting in chemical union are too infrequent to maintain by the heat of their combustion the energy lost by radiation, and consequently the change does not propagate itself and cause an explosion.

Carbonic oxide and oxygen combine slowly at pressures less than an atmosphere when subjected to feeble sparks. Here too the impacts of molecules with a velocity adequate for chemical union are infrequent, as is evident from the fact that the change does not propagate itself.

In the case of cyanogen and oxygen either the feeble spark causes no chemical union, which is improbable, or as in the previous instances the change does not proceed throughout the gas because of the infrequency of impacts of high velocity molecules.

The study of the phenomena of explosives involves the thermal effect, but for the present purpose the heat evolved by the explosion or decomposition of equal volumes will suffice.

Two grams and 2 volumes of hydrogen burn with 1 volume of oxygen, with a thermal result of 58,700 calories, the product gaseous; and 2 volumes of the mixture, therefore, give 39,134 c. Likewise, 2 volumes of carbonic oxide and oxygen give 45,312 c.; 1 volume of hydrogen and 1 of chlorine give 22,000 c.; and 24 grams of solid carbon and 2 of hydrogen unite with an absorption of 48,170 c. to form 2 volumes of acetylene, which evolves this amount of heat when resolved into its elements. In the same way, we have for cyanogen 65,700 c., for nitrous oxide 17,470 c., and for nitric oxide 21,575 c. set free when these compounds are decomposed into their elements. The following table gives the resultant heat of the combination of equal volumes of three mixtures, and of the decomposition of four endothermic gases:

	Resultant heat.	Nature of product.
Hydrogen and oxygen	39134	Gaseous
Hydrogen and chlorine	22000	"
Carbonic oxide and oxygen	45312	"
Acetylene	48170	12/13 solid
Cyanogen	65700	12/21 "
Nitrous oxide	17470	Gaseous
Nitric oxide	21575	"

The molecular heats at constant volume of H_2, O_2, N_2, CO, NO, and HCl are 4·2 to 5, and of N_2O, H_2O, and CO_2, about one-half larger. Those of C_2H_2 and C_2N_2 do not appear to have been determined, but they are probably not greater than 10. Evidently the molecular heats have little influence in determining the temperature at which explosion occurs, and the resultant heat does not account for the fact that the ignition temperature of chlorine and hydrogen is much lower than that of hydrogen and oxygen, or of carbonic oxide and oxygen.

Acetylene requires a pressure 20 times greater than detonating gas for explosion, while the heat of decomposition of the former exceeds that of chemical union of the latter. At temperatures not high enough to cause acetylene to separate completely into its elements or cause detonating gas to explode, the two gases exhibit similar deportment in this respect, namely, that the change is one of slow combination. Acetylene polymerizes to form C_6H_6, C_8H_8, and other condensation products, and detonating gas forms water. But acetylene, when sparked under sufficient pressure, decomposes completely into carbon and hydrogen. The impacts of acetylene molecules with a certain velocity causes them to combine with each other, but when they have a higher velocity complete decomposition results. The change started by a spark in dense acety-

lene propagates itself throughout the gas. About the path of the spark there are sufficiently numerous encounters of molecules with a velocity adequate to cause decomposition, and the heat resulting is not lost by radiation before other molecules of acetylene are decomposed. Thus the change continues until only solid carbon and stable molecules of hydrogen remain. A proposed method for the commercial production of lampblack depends upon this fact. When, however, a spark passes through the gas at common pressure, the change occurs only in the path of the spark. Here the impacts of molecules with a velocity adequate to cause decomposition are more infrequent than in the denser gas—too infrequent, as the result shows, to propagate the change. The heat about the path of the spark is dissipated by radiation before it decomposes neighboring molecules. The infrequency of impacts allows sufficient time for radiation, and for the molecules to assume a stable condition. It is also probable that some more stable molecules, such as C_6H_6, are formed. If acetylene issuing from a tube is lighted, the decomposition does not extend into the tube for the same reason that it does not extend through the gas when sparked at ordinary pressure.

The deportment of acetylene under high pressure, when subjected to small sparks (p. 324) is similar to that of detonating gas.* Condensation products are formed in one case and water in the other. The minute spark imparts to the molecules of acetylene energy adequate to effect combination, and as the spark is visible we assume that the portion of the gas which is glowing has a temperature at which acetylene decomposes when larger quantities are heated. Thus the infrequency of impacts of molecules of high velocity is the real reason why feeble sparks do not start an explosion in dense acetylene.

The non-explosion of cyanogen (p. 325) under high pressure when sparked, although it is more endothermic than acetylene, is doubtless connected with the fact that it requires a higher temperature for its decomposition than the latter; or it may be that the union of CN with CN is exothermic, while the radical itself is endothermic. Nitrous oxide and nitric oxide are stable at high temperatures and these also do not decompose with explosive violence when sparked under pressure. It is probable that all three of these endothermic gases would explode if sparked under pressure and at a temperature approaching that at which they dissociate.

* This Journal, iv, 51.

Recapitulation.

Detonating gas, a mixture of carbonic oxide and oxygen, one of cyanogen and oxygen, and other explosive mixtures of gases do not explode below certain pressures when sparked: and the decomposition of acetylene does not propagate itself at pressures less than two atmospheres. In the path of the spark chemical changes occur which do not extend throughout the gases, and the same is true of a weak spark in the gases mentioned when under a pressure at which a strong spark explodes them. It appears for reasons already stated that explosions do not occur in the instances given only because of the infrequency of impacts of molecules having a velocity or internal energy adequate for chemical union. In the rare gas the impacts are less frequent than in a dense gas, the mean free path is longer, and there is more time for a molecule with energy adequate for combination to lose this energy by radiation and to attain a condition unfavorable to chemical union. Some of the molecules combine, but the heat of their union is not sufficient to restore the energy lost by radiation and the change is therefore not self-propagating. The same explanation holds good for the phenomena of feeble sparks in a dense explosive gas where in the path of a spark there are relatively few molecules with energy adequate for combination, and these collide with each other less frequently than with the molecules not having such energy. In a dense gas a given quantity and a degree of heat, that is, sufficient frequency of molecular impacts, is requisite to secure spontaneous extension of the change.

Art. XXXVI.—*On the Occurrence of Paleotrochis in Volcanic Rocks in Mexico;* by Henry S. Williams.

Introductory Note.—This article was written, Nov. 22, 1897, at the time of the study of the specimens sent by Dr. Dugès, but for various reasons was not then published. A discussion in the Geological Society last December led the writer to refer to these specimens as proof of the non-organic nature of Paleotrochis. Later the Mexican specimens, together with the manuscript copy of this paper, were sent to Mr. Walcott and then to Mr. Diller in confirmation of the inorganic origin, and association with igneous rocks, of Paleotrochis. It is thought best to publish these facts for what they are worth, in connection with Mr. Diller's thorough study of the subject as presented in the following paper.

Some specimens sent to Yale College for identification, by Dr. Alfred Dugès of Guanajuato, Mexico, throw some light upon the nature of the peculiar forms described by Emmons under the name of Paleotrochis. The specimens come from what appears to be an old eroded volcanic cone made up of "Porphyre altéré," "Peckstine rouge" and volcanic tuffs, situated northeast of Guanajuato in the Santa Rosa Mountain range. Among the specimens are several fragments of much altered fragmental as well as massive volcanic rocks. One specimen is filled with amygdules.

The majority of the specimens are composed of milky quartz of the shape called Paleotrochis by Emmons, with variations in form which are particularly suggestive. These suggestive variations are the imperfect form, one-sided, or as if made up of several of the conical halves of typical paleotrochis joined together at their bases, some of the cones being very broad and nearly flat, but each having the appearance of accretion from the small end which in the lower cones is near the center. When thus nearly flat the lines of concentric accretion are evident, while the cones with less angle of slope show the radiating lines more conspicuously. The suggestion furnished by their study is that they were formed in a manner similar to that of the formation of ice columns under a loose soil, which at about freezing temperature sometimes grow to several inches in length. The lengthening of the column of ice, in the latter case, appears to be due to additions of ice forming as soon as the cool atmosphere is reached, while the temperature of the soil is still enough below freezing to permit the water to be drawn up by capillary flow to the surface as the freezing removes it from the surface immediately below.

In the case of the Paleotrochis the application of the suggestion would be in this wise: If a porous rock, had arising through it from below, superheated waters carrying solution of silica, a point might be reached when suddenly the looseness of the rock would permit of rapid radiation upwards of heat, while below the temperature of the heat would be high and remain nearly constant for a long period. Such conditions might occur along the plane of a considerable exit of the rising waters, the rocks below being saturated with the heated waters and above the rock being more or less open by the absence of water. I conceive that, at the junction, a condition might occur in which silica would begin to deposit on the interior of a cavity, but the supply of silica, or of silicated waters, would be furnished only as it was abstracted by solidification. Thus at the points where solidification began the cavity would be increased by the crystallization, and into this cavity more silicated waters would arise; thus the accretion-surface would increase with the lengthening of the cone by the separation of the apices of the cones; consolidation taking place at the point of meeting of the solidified silica with the water, and the water reaching that point slowly.

If some such explanation be the fact, the association of these peculiar forms with gold is explained. Also that such conditions should occur in volcanic regions and particularly in the midst of volcanic tuffs, as in the Mexican case, is as would be expected.

Nov. 22, 1897.

ART. XXXVII.—*Origin of Paleotrochis;* by J. S. DILLER.

PROF. EBENEZER EMMONS,* while State Geologist of North Carolina, discovered among the so-called Taconic rocks of Montgomery County, in that State, a number of more or less regularly striated bi-conical forms to which he gave the names Paleotrochis major and minor, and regarded them as siliceous corals as well as the oldest representatives of animal life upon the globe. According to Emmons Paleotrochis varies in size up to two inches in diameter, and occur with many almond-shaped concretions, often within concretions, in a series of beds over 1,000 feet in thickness interstratified with beds of granular quartz, conglomerate and quartzite. Both species of Paleotrochis have the form of "a flattish double cone applied base to base" with the surfaces grooved somewhat irregularly from near the apex to the basal edge. The smaller form, P. minor, has the "apex of the inferior side excavated or provided with a small roundish cavity" and the other apex "supplied with a small rounded knob, from the base of which the radiated grooves begin." The larger form, P. major, "differs from the foregoing (P. minor) in the absence of the roundish apical depression of the lower side and the knob of the opposite side."

Prof. Emmons regarded Paleotrochis not only as originally siliceous but also gemmiferous, thus accounting for knobs as well as irregular adhering groups, and it is important to note that he reports "these fossils also occur in a variety of quartz or quartzite which I have described as a buhrstone, and which is often porphyrized."

Prof. James Hall,† after an examination of many specimens, regarded the Paleotrochis of Emmons as nothing but concretions in quartz rock. Prof. O. C. Marsh‡ examined the forms microscopically and found them composed of fine-grained quartz, but no trace of organic structure could be detected. While maintaining its inorganic nature he regarded it as difficult to explain, and considered it as having some analogy with cone-in-cone, which he thinks is probably due to the action of pressure on concretionary structure when forming.

The most extensive paper on this perplexing form is that of Mr. C. H. White,§ who strongly advocates the organic nature

* Geological Report of the Midland Counties of North Carolina, 1856, page 62, also this Journal, II, vol. xxii, page 390, and vol. xxiv, page 151.

† This Journal, II, vol. xxiii, page 278.

‡ This Journal, II, vol. xlv, page 218.

§ Journ. of the Elisha Mitchell Scientific Soc., Chapel Hill, N. C., Part 2d, July to December, 1894, pages 50–66.

of Paleotrochis. The specimens he examined were those obtained by Prof. Emmons, as well as a number collected by Prof. J. A. Holmes, the present State Geologist of North Carolina. Mr. White describes in detail not only the peculiarities of the weathered surface of the rock but also the features exhibited upon a fresh fracture, and called attention for the first time to the radial fibrous mineral which he regarded as impure chalcedony. According to Mr. White, the fossil forms are enveloped in chalcedony and the small concretions are made of the same material.

In 1887, Prof. J. A. Holmes* visited the Sam Christian Gold Mine of Montgomery County, N. C., and studied the Paleotrochis-bearing rock in the field. Although he had not then seen any of the acid volcanic rocks from New England, described by Dr. M. E. Wadsworth, or from the South Mountain region of Maryland and Pennsylvania, subsequently described by Dr. G. H. Williams and Miss Florence Bascom, he was of the opinion that the rocks in the neighborhood of the Sam Christian Gold Mine were of eruptive origin. Later observations have convinced him of the correctness of this view. The same opinion is entertained by Messrs. H. B. C. Nitze and George B. Hanna,† who consider the Paleotrochis-bearing rocks at the Sam Christian and Moratock Mines as ancient acid volcanics, and state that "it appears highly probable that at least some of these siliceous pebbly concretions are spherulites." Unfortunately in the preparation of their report time did not permit the authors to study thin sections.

The specimens which, at the request of Mr. C. D. Walcott, the Director of the U. S. Geological Survey, the present writer has had an opportunity to study, consist of a small collection‡ from Mexico sent by Prof. H. S. Williams, besides three fragments about nine inches in diameter sent by Prof. J. A. Holmes, who collected them in 1887 at the Sam Christian Gold Mine, North Carolina, and from the same place several dozen of the original specimens of Paleotrochis major and minor collected by Prof. Emmons. Specimens of the rock and isolated fossils, excepting those from Mexico, have been cut and polished and thin sections prepared for microscopical study.

The rock from North Carolina which contains Paleotrochis is full of nodules of various shapes and sizes, ranging from that of a pin's head to nearly two inches in diameter. These are the supposed concretions and fossils. Upon a fresh fracture the rock appears to be composed chiefly of quartz, but when

* Letter to the author Feb. 6, 1899.

† North Carolina Geological Survey, Bul. No. 3, pages 37 and 39.

‡ See Prof. William's article, this volume, page 335.

weathered most of the nodules become white as if kaolinized, while the other nodules and the matrix remain quartzose in appearance. The nodules form at least two-thirds of the mass of the rock and are arranged with their longer diameters parallel, rendering the rock rather easily split in one direction.

With a lens, it may be seen that the small kaolinized nodules exposed in section upon the surface of a hand specimen have a radial fibrous structure. The same structure may be seen in some of the larger ones, and in addition to this feature some of the nodules possess a more or less distinct concentric shell-like structure. These structures are usually best displayed upon or close to a weathered surface. Portions of the nodules or spaces between them are in a few cases cellular, and the walls of the openings are rarely lined with minute crystals. The supposed fossil forms usually appear conical or discoidal upon a weathered surface. They often show a small cup in the apex and are surrounded by a narrow depression from which the radial fibrous envelope pointed out by Mr. White has been removed by weathering.

A careful comparative study of the nodules in the hand specimens tends to convince one that however different in form and size the supposed fossils and concretions may appear, all belong to one series and have essentially the same origin.

A microscopical study of thin sections of the rock reveals the fact that the nodules are spherulites, a common feature of acid igneous rocks. They are composed in most cases chiefly of fibrous feldspar with quartz or tridymite. As seen in the thin section of the Paleotrochis-bearing rock, the fibers are grouped radially with more or less irregularity in tufts, sheaves, sectors, hemispheres or spheres. When they form a complete sphere, which is rarely the case, they are most coarsely fibrous or granophytic at the center and usually show between cross nicols an indefinite black cross. Occasionally also the concentric structure is well marked. The rays are too minute to permit of an accurate determination of their mineral composition by optical methods, but microchemical tests with hydrofluosilicic acid yield the small cubic crystals, characteristic of potassium fluosilicate as well as the hexagonal prisms of sodium fluosilicate. Judging from the greater abundance of prisms than cubes the fibrous feldspar is richer in sodium than potassium. That feldspar, instead of chalcedony, is the most prominent constituent of the spherulites, is fully borne out also by its kaolinizing under the influence of the weather.

The spherulites are embedded in a matrix composed chiefly of granular quartz. The grains are occasionally so large that the uniaxial positive character can be readily determined. Untwinned feldspar in small grains may be present in con-

siderable amount and yet be easily overlooked. The quartzose character of the weathered matrix, however, shows that at least where most coarsely granular there cannot be much if any feldspar present in it. In places the matrix contains numerous minute parallel scales of what appears to be sericite. Associated with the most coarsely crystalline areas are a few scales of brown biotite and occasionally considerable green biotite, which in places is so abundant as to make quite prominent dark green spots. Both matrix and spherulites are traversed in a few cases by small veins of granular quartz, showing that there is a considerable amount of secondary quartz present. Both spherulites and matrix are rendered slightly microporphyritic by containing occasional crystals of plagioclase, feldspar and quartz. The plagioclase, which, on account of its small angle of symmetric extinction, must be an acid one, in some cases forms the center from which the spherulitic fibres radiate.

An isolated specimen of Paleotrochis was cut through the apices and found to be composed of granular quartz. The quartz was fine-grained upon the outside where the grains were set with their longest axes perpendicular to the adjoining surface. The middle portion contained an irregular iron-stained cavity possibly due to the disappearance of some iron-bearing mineral. Several of the half embedded forms of Paleotrochis were cut in a hand specimen to discover its relations to the enclosing rock, and in each case it formed the interior portion of a spherulite. Most of them contained a dark green patch. The exposed conical surface of one was well striated and there was an irregular depression in the apex. The form was composed chiefly of granular quartz with a yellowish brown to dark green, strongly pleochroic biotite. Near the center is a small spherulite which is not only bordered by finer-grained quartz but is cut by a small vein of it, showing that the deposition of the quartz is subsequent to the development of the spherulite. The embedded portion of Paleotrochis is bordered by spherulitic fibers which run approximately parallel to the slope of the conical surface, and it is evident that the casts of these fibers produce the irregular striæ or grooves upon the surface of the supposed fossil. The embedded portion terminated with an irregularly-pointed apex below. The whole form is fine-grained near the border and sends small veins into the adjoining spherulitic shell. These veins are so small as not to be visible upon a polished surface of a hand specimen even with the aid of a pocket lens, but come out distinctly in the thin section. The spherulitic shell by which Paleotrochis is enveloped is composed of fibers belonging to a number of centers or lines and yet combined they appear to form one

nodule. The biconical form of Paleotrochis suggests that it originated as two spherulite sectors of which the apices were the centers from which the fibers radiated. This would seem to be the simplest way to account for the most regular as well as many of the irregular forms, but of the specimens examined I have not been able to find one that certainly originated in that way.

A number of the fossil forms with a well-marked cup in the exposed apex turned out to be flat hemispherical or thin lenticular in section, and are composed wholly of spherulitic fibers.

Although admitting much irregularity especially on account of the supposed gemmiferous character of Paleotrochis, the ones which have been considered the most characteristic of the fossil are the distinctly biconical forms. These so far as seen are chiefly granular quartz with more or less green biotite.

It is important to note also that the dark groups of green biotite occur in the interior of very irregular nodules which have no suggestion in them of Paleotrochis. Irregular flattened lenticular masses of granular quartz with green biotite occur within the spherulites as well as about them. The green mica is found only in the most coarsely granular groups of quartz.

The following chemical analysis, made by W. F. Hillebrand, shows that the rock has the composition of a rhyolite and accords closely with the results of the microscopical study.

Analysis of the Paleotrochis-bearing rock of Sam Christian Mine.*

SiO_2	79·57
TiO_2	·11
Al_2O_3	11·41 with a very little P_2O_5
Fe_2O_3	·20
FeO	·70
MnO	none
CaO, SrO	·21
BaO	·05
MgO	a very little
K_2O	3·52
Na_2O	3·46
H_2O below 105°	·18
" above "	·61 (ignition)
	100·02

Recognizing the Paleotrochis rock as an acid volcanic full of spherulites, it is easy to understand the great variation in the form of the nodules. Such rocks are in many places distinctly banded and were long considered siliceous sediments, but by

* No other constituents looked for.

the investigations of Wadsworth, Williams, Bascom and others it has been definitely settled that they are all acid volcanics. These rocks in North Carolina are regarded by Mr. Holmes as pre-Cambrian and since their eruption may have undergone great changes like those of the South Mountain described by Miss Bascom. Some of the supposed fossils are certainly spherulites, and all of them may have been originally. Some broken forms show motion in the mass after the spherulites were developed. That Paleotrochis where most perfectly developed and composed of granular quartz is the result of deposition, after the spherulitic growths about it and within it had developed, there can be no question, but whether this deposition followed soon after that of the spherulites in the course of solidification or took place in hollow spherulites (lithophysæ), or resulted perhaps long subsequently at the time of rock alterations, is not so clear. All this and much more will doubtless be cleared up by the members of the Geological Survey of North Carolina, who were the first to correctly identify the rock and the character of the supposed fossil.

None of the Mexican specimens received from Prof. Williams were cut for microscopical examination. Some of them were clearly of igneous origin, and contained amygdules. The Paleotrochis-like forms with radial markings appeared to be composed of secondary quartz and probably originated as those of North Carolina.

About a year ago bi-conical forms like Paleotrochis were presented by Mr. Kochibi, Director of the Geological Survey of Japan, to the U. S. Geological Survey. These specimens are now in the National Museum, and are much more regular in form, size, and general appearance than the Paleotrochis of North Carolina. They are of a pale pink color with regular bi-conical, striated forms, and in some cases have shallow pits in one of the apices. They are known in Japan as "Soroban ishi" or abacus stones. One of these specimens contains a small fragment of the rock from which these curious specimens were obtained, and it appears to be spherulitic. According to Mr. Willis, who obtained the information directly from Mr. Kochibi, "these stones are found only in rhyolitic tuffs. They not infrequently occur much larger than these specimens, possibly up to two inches in diameter or more, and are more frequently associated in groups of two or three overlapping or coalescing. They are generally white, the rosy tint of these specimens being a rare characteristic." A thin section of one of these "abacus-stones" shows it to be an agate of which the outer layers are pink and the inner white. There can be no doubt in this case that the form resulted from the filling of the cavity long after the solidification of the igneous material.

U. S. Geol. Survey, Washington, D. C., March 3, 1899.

ART. XXXVIII.—*On the Association of Argillaceous Rocks with Quartz Veins in the Region of Diamantina, Brazil;* by ORVILLE A. DERBY.

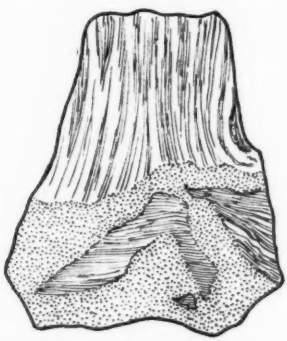
IN a recent excursion in the region about Diamantina, Minas Geraes, Brazil, the frequent association of the decomposition products of argillaceous rocks with the quartz veins with which the underlying metamorphic series of the district is threaded attracted attention. The phenomenon was the more striking because of its absence in a long stretch of road over a newer series in which quartz veins are equally if not more abundant.

The most frequent appearance is that of a selvage to the veins and of intercallations in the mass of the quartz of a reddish foliated clay apparently resulting from the decomposition of a micaceous rock. Less prominent in the surface exposures but quite frequent in the artificial openings that have exposed the inner portions of the veins, are nests and stringers of a structureless white clay (kaolin) that may be either farinaceous or indurated (lithomarge). The red clay was observed in a sufficient number of instances to warrant the assertion that it is a general, if not a universal, feature of the quartz veins of the region and that when it occurs it is constant throughout the entire extension, both lateral and vertical, of the vein. The distribution of the white clay, on the other hand, is patchy and considerable portions of a vein in which it is known to occur may be free from it.

A magnificent exposure of a vein of this character is afforded by the eastern wall of the great cutting of the diamond mines of São João da Chapada, of which an excellent view, reproduced from a photograph, is given in Boutan's monograph on the diamond (Encyclopèdie Chemique de Fremy), and in a recent paper by the present writer in the Journal of Geology (vol. vi, p. 121). Contrary to the description previously given, based on a rapid examination made under unfavorable circumstances and with a limited experience in the identification of decomposed material, this cutting is made along the junction of a conglomeritic diamond-bearing quartzite, and an older fine-grained quartzite (itacolumite), both being profoundly decomposed and in many places indistinguishable except on the closest scrutiny. The eastern wall, which on account of its inaccessibility in the wet season, when it is defended by a frontage of quicksand, and of its superficial staining from the highly-colored overlying soil-cap has been described as a complex of various schists, proves to be a uniform mass of itacolumite with only a single argillaceous member that presents in a striking manner the above-mentioned association with vein

quartz. Throughout the entire length of the cutting, a distance of over 500 meters, runs a sharply-defined layer from 1 to 2 meters thick of argillaceous material with quartz which has received from the miners the name of *Guia* (Guide), because, as they state, diamonds were to be looked for below (or in front) and not above (or behind) the outcrop of this layer.

This layer consists principally of a mass of dark red foliated clay which is evidently a decomposed schist stained with oxide of iron. In several places that afford access to its interior, the central portion is seen to be occupied by an irregular but apparently continuous mass of vein quartz, that sometimes swells out so as to occupy half or more of the thickness of the layer, being in other places reduced to a thickness of a few centimeters only. Associated with the quartz is a pure white granular kaolin which in places is intimately mixed with small angular granules of quartz in a way that suggests a decomposed granite, but in general forms pockets or a selvage in or around the more massive portions of the vein. Outside of the kaolin, when this forms the marginal portion of the vein, or inclosed as angular fragments in its mass, is a minutely banded reddish, or yellowish, micaceous clay that appears to differ from the red clay composing the greater part of the mass of the Guia only in the absence of the intense staining with oxide of iron. The relations of the white kaolin with the banded clay is well shown on the scraped surface of a block that was brought away, and represented about one-fourth the natural size, in the accompanying figure, in which the dotted



portion represents the granular white kaolin and the shaded portion the banded clay. The unshaded streaks in the latter are also of white kaolin that differs from that of the vein in the less distinct granulation, but which in places, as at the lower right hand side, appears to be flame-like apophyses from it.

A very pure specimen of the granular kaolin kindly analyzed by Dr. Hussak gave: SiO_2 44·96 per cent, Al_2O_3 42·09 per cent, H_2O 13·25 per cent. This composition differs from that of a typical kaolin derived from a feldspar only in a slight excess of alumina which may perhaps be due to the precipitation with it of rare elements that are known to occur in the clay.

The quartz and kaolin are so blended that they must be considered as constituting a single geological body, and this can hardly be else than a rock of original granitic, or rather pegmatitic type. Moreover this body from the character of its contact, as shown in the figure, must have been eruptive. The character of the accessory elements is in accord with this view. Those that appear macroscopically are rare prisms of red rutile and handsome tabular crystals and groups of specular iron. The heavy residue obtained by washing is in parts very small, in other parts (where rutile abounds) very abundant, and with the appearance of being wholly authigenetic. It consists principally of rutile partly in rather large sagenitic groups of octahedral form that are evidently pseudomorphs after some mineral of the regular system (possibly titaniferous magnetite) with extremely rare grains of anatase, magnetite, tourmaline and xenotime. The latter is in beautiful glassy prisms with short pyramidal terminations of rather large size that show a tendency towards crystals of macroscopic dimensions such as occur rarely in the concentrates of the mine. The rutile and anatase are evidently secondary, and of the presumably primary accessories, magnetite, tourmaline and xenotime, the latter is the most significant as thus far it is only known *in situ*, at least in Brazil, as an extremely constant and characteristic accessory of the ultra-acid (muscovite) granites and pegmatites. The absence (at least apparent, as in order to avoid admixtures only small quantities could be washed) of its almost constant companions, zircon and monazite, is noteworthy. In this connection it may be recalled that in a recent paper by Dr. Hussak,* on an auriferous quartz vein in the same series near Ouro Preto, these three characteristic granitic accessories were found together, and from this circumstance and from the occurrence of characteristic contact minerals the same conclusion was arrived at, viz.: that the vein is an ultra-acid phase of a granitic apophyse.

The colored clays of the Guia present the appearance of the decomposition products of a micaceous schist. As already stated, the distinct banding of white and colored portions, such as is represented in the figure, in the parts next to the quartz-kaolin vein, is probably due to minute interlaminated projec-

* Zeitschr. f. prakt. Geol., Oct., 1898.

tions from the latter, and in support of this view is the fact that the white bands are distinctly kaolinitic (though not granulated like the kaolin of the vein), while the colored ones are as distinctly micaceous. Aside, however, from these distinct white bands, there is an obscure lamination visible even in the most highly-stained portions. On a carefully scraped surface cut transverse to the lamination a few scattered rounded eyes of quartz are in some portions visible, which with the banded structure are very suggestive of a stretched quartz porphyry. These eyes occur both in the dark red clays and in the lighted colored ones, but are much more abundant in the latter than in the former. This fact taken in connection with the increased staining of the clay towards the margins of the mass and the apparent lack of a physical break between the lighter and the darker colored clays may, perhaps, be taken as an indication that the original rock was more acid in the central and more basic (or at least richer in iron) in the marginal portions of the mass.

On washing, both the dark and the light colored clays give, after a considerable loss as slime, an abundant residue of white micaceous aggregates (in the case of the red clay treatment with acid is necessary) with the aspect of sericite with rare granules of quartz that appear to come exclusively from the eyes. On separation of the mica and quartz by washing or the use of heavy liquids, we find an extremely abundant residue of mixed rutile and anatase (sometimes the one, sometimes the other predominating), which appear to come from original ilmenite represented by abundant black grains in the red and by rather rare, dirty aggregates of ill-formed anatase or rutile in the lighter colored clay. With the titanium minerals occur rarely minute prisms of tourmaline and prismatic fragments, rarely perfect crystals, of monazite of the peculiar type to be described farther on. All the elements of the residue are distinctly authigenetic and in this respect are in marked contrast with those of the adjoining quartzite, which with the same titanium minerals (with the exception of ilmenite) and tourmaline in perfectly fresh crystals contains an abundance of well-rolled zircons.

The Guia is thus a composite body that consisted originally of a vein, or dike, of a quartz-feldspar rock, presumably pegmatitic granite, injected into a micaceous schist that may have been originally either a sedimentary shale or a sheared eruptive. The appearance of the mass is exceedingly dike-like, but if a dike, it must have been injected along a bedding plane, or so nearly coincident with one as to simulate an intercallated layer. The characters above given of apparent porphyritic structure, absence of distinctly clastic elements, and

the presence of monazite, all favor the view of an eruptive origin and appear to be of more weight than those of schistose structure and apparent interbedding with the quartzite which are the most important that can be cited in favor of the opposite view. This question will be discussed farther on.

For an attempt to reconstruct the original rock of the colored portion of the Guia we have the positive indications of a schist free or nearly free from quartz and rich in sericite (or a micaceous mineral resembling it which for convenience will be called by that name), with an abundance of iron and titanium minerals, tourmaline and monazite, as characteristic primary accessories and with an entire lack of distinctly clastic elements which in a series with the degree of metamorphism of that about Diamantina could only be rolled zircons or regenerated tourmalines.* For the purpose of attempting such a reconstruction, specimens were collected of such rocks as from their general aspect might be suspected of representing the original type from which the Guia clays might be derived. From the numerous specimens examined from various localities, the comparative freedom from quartz and the abundance of sericite, of iron and titanium minerals and of tourmaline prove to be common characteristics of the phyllites of the region, which can only be distinguished as presumably original sedimentaries or eruptives by the presence or absence of distinctly rolled zircons (often of a size and abundance that seems extraordinary in rocks presumed to represent fine-grained sediments) and of monazites or zircons, or both, with the aspect of original primary accessories.

The rock which from its position and aspect seemed to be the most promising was a partially decomposed greenish schist found in loose blocks at the foot of the western wall of the cutting, and which, judging from appearances, was thought to have fallen from a layer somewhat similar to the Guia and only a few dozens of meters below it in the same geological series. This, however, proves to be characterized by an abundance of well-rolled zircons and of regenerated tourmalines and by an entire absence of monazite.

Another rock from the immediate vicinity and presumably from the deep rock cutting (mainly in hard itacolumite) for the drainage canal of the Duro mine (seen in the background of the above cited figure in the Journal of Geology), is a thor-

* See Derby, On the accessory elements of itacolumite, etc., this Journal, March, 1898. In this paper it was suggested that the lazulite that occurs quite frequently in the quartzites about Diamantina might have been derived from original clastic phosphates. This view is confirmed by an examination of more abundant material in which distinct but partially altered and corroded monazites and xenotimes were found in the heavy residue of nodules rich in secondary lazulite.

oughly sound, bluish, imperfectly laminated phyllite of which numerous blocks have been built into a wall at the mine-house. Some blocks have in the joint planes handsome plates of specular iron like those of the Guia clay. The rock is for the most part mottled with large yellowish blotches suggestive of enclosed crystals or pebbles, and on a polished cross section shows a minute banding with sheared eyes, corresponding to the blotches, suggestive of a sheared porphyritic rock. The most massive specimen shows evidence of shearing in two planes nearly at right angles to each other, and, in this, part of the original structure which, in the most of the specimens, has been obliterated by the two systems of shearing can still be observed. The appearance under the lens is that of an altered diabasic rock sheared to the point of obliterating the rectangular outlines of the feldspars without completely destroying them. The spots above referred to have the aspect of phenocrysts of feldspar that have lost something of their sharpness of outline. Microscopic sections show a general sericitic mass blackened in irregular bands and patches with a fine dust of iron ores which on being dissolved with acid leave whitish aggregates of a titanium mineral (anatase?). The heavy residue consists of a great abundance of iron and titanium minerals, the latter only rarely showing well-defined forms of rutile and anatase. The only other elements recognizable are rare grains of tourmaline and small prismatic fragments, rarely perfect crystals, of monazite. Some of the grains referred to this mineral may possibly be zircon, but if so they are perfectly fresh (not rolled), but indistinctly characterized. The original rock was apparently a basic eruptive very rich in iron and titanium minerals (ilmenite?) and with rare phenocrysts of the more acid element. So far as can be made out, this rock would on decomposition give exactly the characters of the red clay of the Guia. The principal difficulty in the interpretation of this rock and of the red clay of the Guia as a sheared and metamorphosed basic eruptive is the presence of monazite, which thus far is only known *in situ* in the acid eruptives or their metamorphosed representatives.

Two other rocks from the same region present certain characteristics in common with the one above described and if, as seems probable, they can be genetically connected with it, will serve to establish a graduation into a more acid type on the one hand (thus removing in part the difficulty above noted), and on the other hand into a better-defined basic type. From near the Serra do Gigante, several miles to the northward of São João da Chapada on the road from Diamantina to Grão Mogol, my friend and companion, Dr. Francisco de Paula Oliveira, brought a loose block of a peculiar cyanite-phyllite

full of enormous crystals of cyanite in an imperfectly laminated groundmass of sericitic appearance. The rock is free from iron ores, but extremely rich in minute aggregates of rutile and of extremely minute prismatic needles that are referred to monazite. The original rock was evidently a highly aluminous (feldspathic) one, with an abundance of a titanium mineral (ilmenite?) and of monazite, in which through shearing and the development of secondary minerals, all traces of the original structure has been obliterated. A very similar rock, but lacking the monazite, was found by Dr. Hussak on the Ilha do Fogo in the river São Francisco in front of the town of Joazeiro, where it presents the aspect of a dike in gneiss.

Some 15 or 20 miles to the southward of São João da Chapada, near the fall of the river Dattas close by the town of Gurvêa, another imperfectly laminated phyllite was found outcropping in the road that strongly resembles that of São João but differs principally in the absence of monazite, in the preservation of the original rectangular outlines of the white mineral transformed into sericite, and in the great quantity of tourmaline that is evidently an element introduced in the metamorphism of the rock. In addition to the fine iron dust that on removal by acid leaves a dust of formless aggregates of titanium, the rock contains magnetite in considerable-sized grains and octahedral aggregates of an altered titanium mineral that strongly resembles those of decomposed perofskite described by Hussak from the diamond gravels of Agua Suja (Neues Jahrb., 1894, ii, p. 297). Judging from the sharply cut rectangular outlines of the areas of sericite free from the iron dust, the original rock must have been largely composed of lath-shaped crystals like those of the plagioclase or melilite of diabasic or basaltic rocks, and with this conclusion the great abundance of the iron and titanium dust, that may be presumed to come from original ilmenite, and of magnetite with an octahedral titanium mineral, is in accord. The shearing has not been sufficient to obliterate the form of the white element and appears to have been anterior to the introduction of the tourmaline that lines the joint planes and has invaded many of the rectangular sericitic areas without passing beyond their limits.

There can be no reasonable doubt but that the rock last described is a metamorphosed and moderately-sheared basic eruptive and when it is recalled that "mixed dikes" have been described (see Zirkel, Petrographie, i, p. 784) in which a granite-porphyry passes to a type that has been described as diabase or melaphyre, the hypothesis that the two rocks above described and the decomposed material of the Guia may be genetically related is not so extravagant as at first sight appears.

The most serious objection to bringing the Dattas rock into line with the others is the absence of monazite, but in regard to this it may be noted that this mineral (like the xenotime in the white kaolin) is so rare that it failed to appear in some of the tests made.*

The association of argillaceous material with quartz veins is also a prominent feature in the diamond mines about the little village of Sopa, about a dozen kilometers to the southward of São João da Chapada. The diamond-bearing material is here a decomposed conglomeritic quartzite entirely similar to that now on view in the mines of São João.† This rests unconformably on an older series of quartzites (itacolumites) with intercallated schists that is also profoundly decomposed. This lower series is abundantly threaded with small irregular quartz veins that frequently show included pockets and stringers of indurated kaolin and almost invariably partings and selvages of various colored schistose rocks or clays that closely resemble those of the Guia above described. The white kaolin which is less abundant and constant than in the Guia, affords the same residue of rutile and anatase with rare prismatic grains of xenotime. In a washing from the kaolin of the Bambá mine the residue, consisting almost exclusively of anatase with some grains approaching a macroscopic size, was nearly 0·05% of the quantity washed. In another from Misael's mine the residue is scanty, as in the greater part of the tests from the Guia, and consists principally of rutile with rare grains of anatase. In both the xenotime is in rare individuals, mostly in fragments, of comparatively large size showing a tendency to assume macroscopic proportions.

The schistose accompaniment of the veins at Sopa is, in the few cases observed in which it is well preserved, a well laminated, almost papyraceous, micaceous greenish schist that gives on decomposition an ash-colored, or reddish, clay, not distinguishable, except by its residue, from the clays derived from

* Owing to this circumstance, and to the difficulty of avoiding admixtures, the tests of the material from the Guia in which the rare accessories proved to be infrequent and inconstant, were many times repeated and with special precautions. The identification based on form, optical properties and behavior with heavy liquids was confirmed by microchemical tests for phosphoric acid and for cerium and yttria.

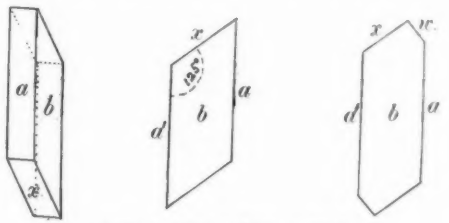
† The question of the diamond in these deposits will be discussed in another place. The conclusion presented in former papers, that the gem occurs in vein material, was based on the examination of a mass shown me in 1880 as a diamond-bearing body, but which I am now convinced was a detached section of the Guia, in which, according to the best obtainable information of the present day, no diamonds have been found, and which presents no evidence of having been worked. On the other hand, it is certain that one of the diamond-bearing bodies not now visible was closely similar to it in appearance, though perhaps not in original character and origin. The section of the Guia examined in 1880 was much richer in tourmaline than the parts washed on the recent visit.

the phyllites intercallated in the series in which the veins occur. A large "horse" left standing in the center of Misael's mine, and decomposed to a yellow ocherous clay, shows to the naked eye abundant pyrite (altered to limonite) and tourmaline, and affords on washing a very slight residue of quartz, much tourmaline in handsome prisms, and a comparative abundance of well-rolled zircons with rare grains of rolled rutile and still rarer ones of sagenite that, like the tourmaline, appear to be authigenetic. An ash-colored clay poorly exposed, only a few meters away and of very similar aspect, affords an entirely different residue characterized by an extraordinary abundance of minute sharp-angled prisms of monazite of peculiar type, with rare tourmaline and still rarer octahedral xenotimes often intergrown with zircon but altered to a yellowish mass that is difficultly distinguishable from the aggregates of titanium minerals so abundant in the various rocks of the region. There is here a complete absence of rolled zircon or of other elements that can be considered as allothigenetic. Specimens from two distinct outcrops of the green schist associated with quartz veins in the immediate vicinity of the mine show, along with much rutile that is evidently of secondary origin, a mixture of the characteristic elements of the two clays above described, that is to say, perfectly sharp crystals of monazite with well rolled zircons, both in considerable abundance. A polished cross-section of one of the more massive pieces of this schist shows a banded structure with alternations of a dark green with an ash-colored material. The two are so intimately interlaminated that they could not be completely isolated so as to give perfectly unmixed residues, but there is an evident concentration of monazite in the green and of zircon in the lighter-colored portion. Thus both the character of the residue and the aspect of the specimens indicate that this schist has been produced by the shearing and metamorphism of a mass of mixed material of which one part, corresponding to the "horse" of the neighboring mine, is characterized by allothigenetic zircons and the other, corresponding to the other clay of the mine, by authigenetic monazite. Thus the veins at Sopa appear to be highly-sheared bodies essentially identical with the Guia but more completely mingled with the adjoining rocks.

The observations above recorded indicate the presence in the older series of the region of dikes of a rock characterized by titanium minerals and monazite as primary accessories that have been sheared and metamorphosed together with the rocks into which they were injected, and that the schistose and presumably weak layers thus produced have more frequently than others been the seat of subsequent injections of pegmatitic material that passes to pure quartz. In the cases examined

the material of the supposed dikes is characterized, with the single exception of the Dattas rock, by the mineral monazite which, so far as at present known, may be taken as peculiarly characteristic of granitic magmas. The original dikes may therefore be presumed to have been acid porphyries, or basic phases of such porphyries. If, however, this conclusion is correct, all eruptives of whatever nature existing in the series previous to the uplifting and shearing must have suffered a similar change and afforded planes of weak strata favorable to the subsequent injection of pegmatites, or of other types of eruptives. In the overlying series to which the conglomeritic diamond-bearing deposits examined belong, the quartz veins observed show none of these characteristics and appear to be ordinary veins of segregation. The same is also the case with the very numerous and large veins observed along about fifty miles of road over a newer series of graywackes, slates and limestones in the region lying immediately to the west of the gold and diamond section of the Serra do Espinhaço. On the other hand, a number of scattered observations indicate that the veins of the gold-mining districts of the Serra do Espinhaço present characteristics similar to those of the diamond district and difficultly reconcilable with the current hypotheses of a purely segregational origin. In the only one that has been critically examined, that of Passagem near Ouro Preto, Dr. Hussak, as already referred, has found characteristic granitic accessories and contact minerals in a great sulphuret vein, and as the somewhat similar veins of the Pary and Morro Velho mines carry garnets in the one case and microscopic zircons in the other, it may be suspected that they will on close examination, for which material is unfortunately not at hand, give a similar result. Dr. Hussak has also shown in his various papers in the Mineralogical Magazine, on the remarkable association of minerals in the cinnabar-bearing gravels of Tripuhy, that these carry monazite and xenotime, the latter of the same type as in the Diamantina district, along with the curious titano-antimoniates of which one has been traced to a sericitic schist very similar in appearance to that above described, and to a pyritiferous sericitic schist found in place in the immediate vicinity in which rare prismatic fragments of monazite of the Sopa type were detected. Lithomarge with other peculiar clays are, with quartz, characteristic features of the topaz and euclase-bearing veins near Ouro Preto, and lithomarge is a constant accompaniment of the peculiar gold and iron-bearing *jacutinga* veins (?) in the iron ore beds of the same region. Thus the association of argillaceous materials with quartz veins is wide spread and varied in its occurrence, and the observations here recorded are suggestive of the necessity of a careful revision of the current hypothesis regarding the segregational origin of many of these veins.

Both the monazite and the xenotime of the clays and rocks above described and of the concentrated washings of the mines to which they have contributed, present peculiarities of form that distinguish them from the types that have hitherto been found in place in Brazilian, or other, rocks. The monazite crystals are invariably in elongated prisms with only the pinacoid plane developed giving forms that exactly resemble simple prisms of zircon with broken terminations. The extremities are most frequently broken, but occasionally one or two terminal planes are observed as in the accompanying figure kindly drawn by Dr. Hussak. The smallness of the extinction



a (100), *b* (010), *x* ($\bar{1}01$), *w* (101).

angle (1°–4°) increases the resemblance to zircon, which is so close that only by chemical tests and the measurement of the angles (for which material of sufficient size was fortunately found in the diamond concentrates) could their true character be determined. The xenotimes are invariably elongated prisms with pyramidal terminations in strong contrast with the octahedral type, which is the only one hitherto found in the numerous rocks containing the mineral that have been examined. The crystals when perfect are as transparent and lustrous as zircons, but are quite subject to a milky alteration and are extremely brittle. They rarely sink to the extremely minute size of the generality of the monazite crystals and show a tendency to assume macroscopic proportions. Brown opaque crystals of this prismatic type up to 10 millimeters or more in length, are quite abundant in the concentrates of the mines about the village of Dattas, a few miles to the southward of the localities above described, and there can be no doubt that they come from quartz and kaolin veins like those of São João da Chapada and Sopa. The octahedral type which commonly occurs in the monazite-bearing granites and porphyries, and which was actually found in one of the clays from Sopa, is comparatively rare in the concentrates examined from the Diamantina region, but is abundant and of macroscopic proportions in those from the Lençoes region in Bahia. Perhaps its tendency to alteration noted in the Sopa clay may explain its rarity.

Since the above was written I am enabled, through the extreme kindness of Profs. Clarke and Hillebrand of the U. S. Geol. Survey, to add the following very minute and painstaking analysis of the peculiar rock from the Serra do Gigante, which, as indicated in the above discussion, is the most promising for giving an idea of the hypothetical original rock type from which the various schists here described may be presumed to be derived. At my request special attention was given to the detection of rare elements of which those of the cerium group and lithia were, from a preliminary examination, presumed to be present in an abundance that failed to be verified. Contrary to expectation, the rock proves to be chloritic rather than sericitic, though, as I am informed, the petrographic examination made in Washington confirmed the opinion formed here that the appearance of the predominant micaceous element is that of a muscovite mica. Contrary to expectation also, the rock proves to be basic rather than acid, and thus the principal difficulty in the way of the attempted affiliation with the Dattas and São João schists of diabasic, or basaltic, aspect is removed. On the assumption, based on the complete absence of recognizable allothigenetic elements, that the original rock was eruptive, no affiliation with any known type of which analyses are at hand can be made.

Analysis of Cyanitic schist, from Serra do Gigante, near Diamantina, Brazil, by W. F. Hillebrand.

	Whole mass.	HCl extract.	H_2SO_4 ext.	Residue insol. in H_2SO_4
SiO_2	38·32	10·78	14·76	(23·56)
TiO_2	4·93	·10	·20	(4·73)
ZrO_2	·09	trace ?	?	(·09) ?
Al_2O_3	28·16	10·42	14·77	(13·39)
Fe_2O_3	2·24	(1·78)	(2·24)	none
FeO	4·02	(3·21)	(4·02	"
(Ni, Co)O	·04	?	(·04)	----
MnO	·16	?	(·16)	----
CaO	·32	·34	·32	----
SrO	trace	?	?	----
MgO	12·04	9·34	(12·04)	none
K_2O	1·11	·26	(·26)	·85
Na_2O	·16	(·03)	(·03)	·13
Li_2O	strong trace	strong trace	(strong trace)	faint trace
H_2O, 105°	·55	(·55)	(·55)	----
H_2O, 220°	·45			
H_2O, 310°	·22	5·36	6·80	·66
H_2O, 310°+	6·79			
P_2O_5	·47	·47	(·47)	----
S	trace	----	----	----
F	trace ?	----	----	----
	100·07	42·64	56·66	43·41

No boron, nor rare earths.

Notes to the Foregoing Analyses.

"The bracketed figures are either assumed or follow from direct determinations in one of the other columns.

An hour's treatment with concentrated sulphuric acid is sufficient for extraction of all the soluble constituents. Probably very prolonged action of hydrochloric acid would have had the same effect. The silica from the decomposed silicates separated on rotation in the insoluble form. The lithia belongs to a soluble mineral, for but a faint trace was found in the residue. The P_2O_5 is wholly extracted by dilute nitric acid; it can therefore hardly exist as monazite. Moreover, careful tests failed to show a trace of rare earths. Still the lime is quite insufficient to form apatite with all the P_2O_5.

No formula for the soluble portion can be calculated from the analyses, but according to Professor Clarke it would seem to approach in composition an impure earthy chlorite.

The insoluble residue, after treatment by hydrofluoric and sulphuric acids, contained besides a large amount of unattacked rutile, practically only silica and alumina in the proportions required for cyanite. Assuming that the alkali of the residue belongs to sericite, as indicated by Professor Derby's letter accompanying the specimen, and deducting accordingly for the formula of typical muscovite ($KH_2Al_3Si_3O_{12}$), the following percentages remain after excluding all TiO_2 as rutile: SiO_2 19·62, Al_2O_3 10·24, H_2O ·27. Again assuming that the alumina exists herein as cyanite and deducting Al_2O_3 and SiO_2 to correspond, there remains 13·66 per cent of free silica. This can hardly be opaline silica, for an hour's digestion of the insoluble residue with strong potassium hydroxide solution extracted but a fraction of a per cent of silica."

In view of the apparent disaccord in some points of this analysis with the results above recorded of the physical examination with batèa, heavy liquids and microscope, the latter has been repeated with special care and on a sufficient quantity (20 grams or more) to secure a reliable result. The presence in considerable abundance of free quartz and of rutile was fully confirmed, but no reliable trace of apatite or of zircon could be found. The former if present at all, which is doubted, must be in a proportion too small to account for more than an extremely minute portion of the phosphoric acid and lime, and the latter is certainly absent. The zirconia found in the analysis must be from some other mineral and presumably from the soluble constituents of the rock. A mineral closely resembling zircon, and like it heavier than cyanite, is completely dissolved out of a mixed residue by sulphuric acid, and in the solution very satisfactory tests for phosphoric acid and cerium were obtained, the latter being precipitated as oxalate, and verified by the Florence method in both a borax and salt of phosphorus

bead. Isolated grains gave also a very satisfactory microchemical reaction for phosphoric acid and a somewhat doubtful one for cerium, but no definite reaction for the latter could be obtained by the blowpipe method, probably on account of the smallness of the quantity of pure material available or of some disturbing admixture. On the strength of these observations and of the close resemblance in form and optical properties with the mineral from the Sopa clay, the original determination as monazite is maintained. The Sopa mineral is undoubtedly a cerium phosphate and apparently agrees in form with submacroscopic crystals from the diamond concentrates on which the angles of monazite were verified. It appears, however, to carry some titanium and lime, and possibly this peculiar type of monazite may present peculiarities of composition. The facility with which the mineral can be isolated from the Sopa schist gave an opportunity to determine roughly, by washing, its proportion as about 0·01 per cent. It is apparently much less abundant in the Serra do Gigante rock and therefore could hardly be expected to appear in the quantity ordinarily employed in a chemical analysis. It seems probable also that this rock carries some other undetermined phosphate.

Commissão Geographica e Geologica,
S. Paulo, Brazil.

Art. XXXIX.—*Goldschmidtite, a New Mineral;* by William H. Hobbs.

The analyses of Hillebrand and the crystallographical studies of Penfield which were made in connection with the monograph of Cross and Penrose* on the Cripple Creek Mining District have established the fact that the chief telluride ore of the district is the mineral calaverite, containing about three per cent, or less, of silver. The presence of this mineral in the ores had previously been determined by Knight† by chemical analysis. Mr. R. Pearce‡ of Denver had, however, assayed an ore-bearing rock from the Moose Mine, and found it to contain gold, silver, and tellurium in proportions corresponding with sylvanite, so that he believed this mineral to be present. From the complex nature of the material assayed these results can hardly be regarded as conclusive, but to the writer they would seem to indicate at least the probability of the presence of a gold-silver telluride, richer in silver than calaverite, particularly since the output of silver from some of the mines is too large to be fully accounted for by the presence of calaverite alone. Dr. Hillebrand says:

"Notwithstanding that sylvanite has not been identified by positive chemical or crystallographical tests, the evidence of Mr. Pearce as to its presence in some portions of the district at least is entitled to consideration" (l. c., p. 133).

Source of the Material examined.

The material which I have studied was kindly given me for examination by Mr. Gustavus Sessinghaus, a graduate of the Columbia School of Mines, and now a graduate student of the University of Wisconsin. It was obtained from the Gold Dollar Mine in Arequa Gulch, in the extreme southwestern portion of the Cripple Creek Mining District. This mine is located on the northwest quarter of Section 31. (Cf. Plate VII, l. c.) It is near the flank of Grouse Mountain. The material consists of a single small hand specimen, the matrix of which is a breccia in which fragments of granite are conspicuous. Comparison with the gneissose granite of Grouse Mountain shows that the enclosures in the rock have probably been derived from that source. The cementing material of the breccia resembles the phonolite of the region, with

*Geology and Mining Industries of the Cripple Creek District, Colorado; by Whitman Cross and R. A. F. Penrose, Jr. 16th Ann. Report, U. S. Geol. Survey, 1894–5, Pt. II, pp. 1–209.

† Proc. Colo. Sci. Soc., Oct. 1, 1894. ‡ Ibid., April 5, 1894.

which it probably corresponds in composition. The fragments of the breccia are, however, only loosely consolidated, so that the specimen is crossed by numerous irregular cracks, the walls of which are coated with chalcedony.

The crystals of the mineral which is here discussed are firmly attached to the chalcedony, so that great difficulty was experienced in removing them without fracture, particularly as they are possessed of a perfect cleavage. These crystals have a rather long columnar habit with some tendency also to elongated tabular forms with reference to a plane parallel to this axis, and in one or two cases they were observed to have the arborescent forms which have given the name "Schrifterz" to the mineral sylvanite, and have been explained by twinning. The largest individual observed was only about 5^{mm} in length and those which I have succeeded in separating from the chalcedony of the walls would average hardly 2^{mm} in length, with a thickness perhaps a third or a fourth as much. Examination with the lens showed these crystals to be considerably modified and without striation or other distortion, and, except for their minute size, they are admirably suited to measurement. They have a perfect cleavage following the plane of their tabular development. They are seen to be often twins, the plane of twinning following the columnar axis in a direction normal to the cleavage. They are quite brittle and have a hardness of about 2, since they will just scratch the surface of selenite. The amount of material was not sufficient for a satisfactory determination of the specific gravity, but the mineral's composition as recorded below, and the comparison of it with sylvanite and calaverite, make it probable that the specific gravity is very near to 8·6. The luster of the mineral is bright metallic and the color a silver white. The streak is dull, grayish black.

Chemical Composition.

Examined on charcoal before the blowpipe, the mineral readily fuses surrounded by the light bluish green flame which is characteristic of tellurium, leaving on the coal a white coating of tellurium oxide. A yellowish white button of gold and silver results from the fusion, as in the cases of sylvanite and calaverite, though it is much less yellow than the button obtained from the last mentioned mineral. No antimony, sulphur, or selenium could be detected.

A portion of the specimen was broken up and by careful and laborious picking out of the crystals and fragments of crystals about one-tenth of a gram of nearly pure mineral was obtained, which was analyzed and found to contain gold, silver, and tellurium, in the following proportions, the tellurium being estimated by difference:

	Percentage composition.	Ratio.
Au	31·41	·1596
Ag	8·95	·0831
Te	(59·64)	·4771
	100·00	

These proportions correspond almost exactly with the formula Au_2AgTe_6, and show that the mineral is a new species, which I propose to call Goldschmidtite, in honor of my friend, Professor Victor Goldschmidt, of Heidelberg, the inventor of the two-circle goniometer and the author of *Index der Krystallformen* and *Winkeltabellen.*

Below are given in parallel columns the estimated and the theoretical proportions of the constituents of this mineral on the basis of the formula Au_2AgTe_6:

		Calculated.
Te	(59·64)	59·95
Au	31·41	31·44
Ag	8·95	8·61
	100·00	100·00

Relationships with other Tellurides of Gold and Silver.

The mineral sylvanite contains the same elements as Goldschmidtite but in the proportions represented by the formula $AuAgTe_4$.* The mineral calaverite differs in being richer in gold and is not generally credited with a definite formula, because of slight variations noted in the content of silver. The number of analyses of this mineral which have now been made renders it possible, as it seems to me, to arrive at a more definite formula than $(Au,Ag)Te_2$, which assumes an isomorphous relation between gold and silver in the compound that does not exist so far as we know. Comparison of the analyses of calaverite which are given below brings out their striking uniformity with the exception of the silver percentage, and this would seem to indicate that a mineral corresponding to the one having the highest silver percentage (3·52) may form isomorphous mixtures with one that is richer in gold or perhaps entirely free from silver. Since, however, a large proportion of the analyses contain silver in amounts approximating the maximum percentage, it is improbable that isomorphous mixtures occur with tellurides much richer in silver. The formula $Au_9Ag\frac{5}{3}Te_{21}$ seems best to represent the composition of this mineral.

* Groth, Tabellarische Uebersicht der Mineralien, 4te Auflage, Braunschweig, 1898, p. 28.

Analyses of Calaverite.

	Te	Au	Ag	Total
1. California, Genth*	55·89	40·70	3·52	100·11
2. " " †	(56·00)	40·92	3·08	100·00
3. Bowlder Co., Colo. Genth‡	57·67	40·59	2·24	100·50
4. " " " §	57·32	38·75	3·03	99·10
5. Cripple Creek, Colo. Hillebrand‖	57·60	39·17	3·23	100·00
6. " " " ¶	57·40	40·83	1·77	100·00
7. " " " **	57·30	41·80	·90	100·00
Calaverite of formula $Au_9Ag\frac{5}{3}Te_{21}$	57·40	39·08	3·52	100·00

Comparison of the minerals calaverite, Goldschmidtite, and sylvanite brings out the fact that Goldschmidtite is, as regards its composition, intermediate between calaverite and sylvanite and almost exactly half way between them. Together the three minerals represent an homologous series quite analogous to that which has been determined for the minerals of the humite group by Penfield and Howe.†† This will be clear from the following table:

	Te		Au		Ag	
	Per cent.	Ratio.	Per cent.	Ratio.	Per cent.	Ratio.
Calaverite	57·40	·4544	39·08	·1987	3·52	·0327
$Au_9Ag\frac{5}{3}Te_{21}$	(21 = ·4536)		($\frac{2}{3}\frac{7}{7}$ = ·1944)		($\frac{5}{3}$ = ·0363)	
Difference	2·55	·0256	7·54	·0388	5·09	·0473
Goldschmidtite	59·95	·4800	31·44	·1600	8·61	·0800
Au_2AgTe_6	(22 = ·4752)		($\frac{2}{3}\frac{2}{2}$ = ·1584)		($\frac{1}{3}\frac{1}{1}$ = ·0799)	
Difference	2·20	·0176	6·99	·0336	4·79	·0444
Sylvanite	62·15	·4976	24·45	·1244	13·40	·1244
$AuAgTe_4$	(23 = ·4968)		($\frac{1}{3}\frac{7}{7}$ = ·1235)		($\frac{1}{3}\frac{7}{7}$ = ·1235)	

From the above table it is seen that the common difference between consecutive members of the series in ascending order is a gain of Ag_2Te and a loss of $Au\frac{5}{3}$. For purposes of comparison the formulæ of the three minerals should therefore be written:

Calaverite ..... $Au\frac{2}{3}\frac{7}{7}Ag\frac{5}{3}Te_{21}$.
Goldschmidtite ..... $Au\frac{2}{3}\frac{2}{2}Ag\frac{1}{3}\frac{1}{1}Te_{22}$.
Sylvanite ..... $Au\frac{1}{3}\frac{7}{7}Ag\frac{1}{3}\frac{7}{7}Te_{23}$.

The next member of the series should have the formula:

$$Au\frac{1}{3}\frac{2}{2}Ag\frac{2}{3}\frac{3}{3}Te_{24}$$

* This Journal, xlv, 1868, p. 314. † Ibid.
‡ Am. Phil. Soc., xiv, 1874, p. 229. § Ibid., xvii, 1877, p. 117.
‖ 16th Ann. Report U. S. G. S., Pt. II, p. 133. ¶ Ibid. ** Ibid.

Note.—The mineral krennerite is a telluride of gold and silver richer in silver than sylvanite, but the wide and remarkable variations in the proportions of its constituents cause it to be regarded as of very indefinite composition.

†† On the Chemical Composition of Chondrodite, Humite, and Clinohumite. This Journal, xlvii, 1894, p. 188–206.

which is a close approximation to $Au_1Ag_2Te_3$. The mineral krennerite contains silver in about this proportion (19·44 per cent), but the proportions of gold and tellurium do not correspond.

Crystallography of Goldschmidtite.

As already stated, the chief difficulty encountered in measuring the crystals has been their minute size and the consequently small amount of light reflected from their faces. A number of the better faces afforded single images of the signal so that in the prism zone, where the faces were largest, consecutive readings from the same angle showed variations of less than a minute of arc, and on the best crystal the four similar angles between prism and pinacoid were respectively:

61° 42′
61 46
61 46½
61 47½

Considerable confidence is therefore placed in the correctness of the constant which was determined from the angles in this zone, while the values of the other constants are correct only within limits of error which are sufficiently indicated by a comparison of observed and calculated values of readings of interfacial angles. Five crystals have been completely measured and particular angles have been measured also upon other crystals.

The symmetry of the mineral is easily determined as monoclinic, and it is probably also clinohedral. The principal zones of the crystal are those of the axes c and $\bar{b}$, a single clinodome and a pyramid which was too small to be determined being the only faces not included in these zones. Owing to the frequent absence and the small development when present of the basal pinacoid, the angle β was determined from the mutual inclinations of the positive and negative unit orthodomes and found to be 89° 11′. The axial ratio $a:b:c$ is 1·8562 : 1 : 1·2981. The crystal forms observed number twenty-two, and are as follows:

Zone of c.— a (100) $i\text{-}\bar{1}$; b (010) $i\text{-}\dot{1}$; m (110) I; f (210) $i\text{-}\bar{2}$; g (310) $i\text{-}\bar{3}$; t (370) $i\text{-}\frac{3}{7}$; l (130) $i\text{-}3$.

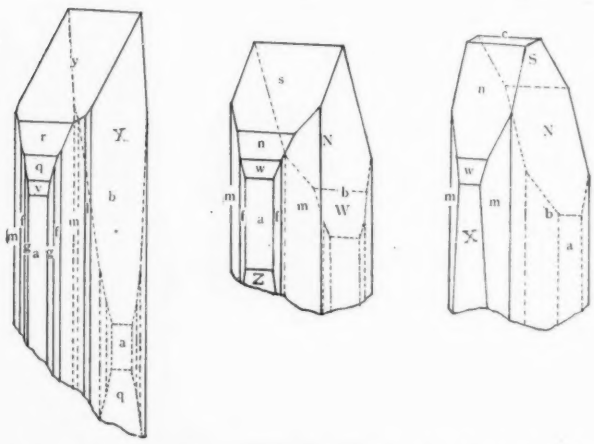
Zone of $\bar{b}$.— y (508) $-\frac{5}{8}\text{-}\bar{1}$; s (101) $-1\text{-}\bar{1}$; n (201) $-2\text{-}\bar{1}$; r (703) $-\frac{7}{3}\text{-}\bar{1}$; w (401) $-4\text{-}\bar{1}$; q (801) $-8\text{-}\bar{1}$; x (10·0·1) $-10\text{-}\bar{1}$; v (35·0·1) $-35\text{-}\bar{1}$; S ($\bar{1}$01) $1\text{-}\bar{1}$; N ($\bar{2}$01) $2\text{-}\bar{1}$; W ($\bar{4}$01) $4\text{-}\bar{1}$; X ($\bar{1}$0·0·1) $10\text{-}\bar{1}$; Z ($\bar{1}\bar{4}$·0·1) $14\text{-}\bar{1}$; c (001) O.

Zone of $\dot{a}$.—k (032) $\frac{3}{2}\text{-}\dot{1}$.

The more important angle readings from which these determinations were made are as follows:

				Obs.	Calc.	Diff.
a : *m*	(100)	:	(110)	61° 41′*		
b : *m*	(010)	:	(110)	28 18	28° 19′	−1′
a : *f*	(100)	:	(210)	42 43	42 52	−9
a : *g*	(100)	:	(310)	31 55	31 45	+10
b : *l*	(010)	:	(130)	9 57	10 11	−14
b : *k*	(010)	:	(032)	26 49	27 18	−29
a : *y*	(100)	:	(508)	65 7	65 42	−35
a : *s*	(100)	:	(101)	54 57	54 29	+28
a : *n*	(100)	:	(201)	34 13	35 17	−64
a : *r*	(100)	:	(703)	31 40	31 17	+23
a : *w*	(100)	:	(401)	19 10	19 35	−25
a : *q*	(100)	:	(801)	10 3	10 6	−3
a : *x*	(100)	:	(10·01)	7 44	8 7	−23
a : *v*	(100)	:	(35·01)	2 22	2 20	+2
a : *c*	(100)	:	(001)	89 25	89 11	+14
b : *c*	(010)	:	(001)	89 59	90 0	+1
b : *t*	(010)	:	(370)	12 53	13 0	−7
a : S	(100)	:	($\bar{1}$01)	55 35*		
a : N	(100)	:	($\bar{2}$01)	34 58	36 0	−62
a : W	(100)	:	($\bar{4}$01)	19 18	19 46	−28
a : X	(100)	:	(1$\bar{0}$·01)	7 48	8 9	−21
a : Z	(100)	:	($\bar{1}\bar{4}$·01)	5 49	5 44	+5
b : *k*	(010)	:	(032)	26 49	27 18	−29

1. 2. 3.



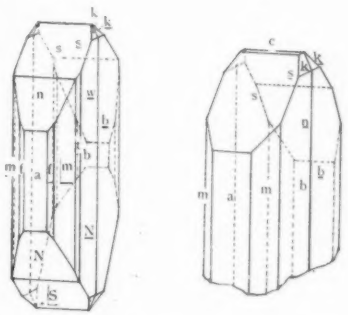
Of the five crystals measured, crystal I (fig. 1) is bounded by the forms *a*, *b*, *m*, *f*, *g*, *l*, *v*, *q*, *r*, *y*, and X. Crystal II (fig. 2) is bounded by *a*, *b*, *m*, *f*, *w*, *n*, *s*, Z, W, and N. Crystal III (fig. 3) exhibits the combination *a*, *b*, *m*, *c*, *w*, *n*, X, N, and S.

Crystal IV (fig. 4) is doubly terminated and represents a simple twin with the twinning plane the orthopinacoid. One of its individuals (the front one in the figure) displays the forms *a*, *b*, *m*, *f*, *t*, *n*, *s*, N, S, and *k*. The other individual differs in having only one positive orthodome (N) and the form *w* in place of *n*. Crystal V (fig. 5) is also a twin crystal, on the front individual of which are developed the forms *a*, *b*, *m*, *c*, *k*, and *s*. The other individual exhibits in addition *n* and lacks the basal pinacoid. A small pyramid lying between *k* and *s* I was unable to determine. All the crystals show a remarkably perfect cleavage following the plane of symmetry.

Crystallographical Affinities of Goldschmidtite and Sylvanite.

As might be expected from its chemical relationship to sylvanite, the mineral Goldschmidtite exhibits affinities also in its crystal development. Both minerals have monoclinic symmetry and somewhat similar forms are developed upon them. Ten of the twenty-two forms discovered on Goldschmidtite have representatives on sylvanite. Below are given in parallel columns the crystallographical constants of the two minerals and some of the angle readings between faces of corresponding forms. It will be noted that the differences are greatest in the prism zone, where the largest faces of Goldschmidtite make the error of reading comparatively small. The orientation of sylvanite is that of Schrauf, which is now generally adopted.

4. 5.



The axes *a* and *c* are each about one-seventh longer in Goldschmidtite than in sylvanite. It is to be regretted that satisfactory material is not available for the crystallographical study of calaverite. That studied by Penfield* was so poor that he was unable to determine the crystallographical constants. He thinks the mineral is probably triclinic, with its angles somewhat similar to those of sylvanite. It lacks the pinacoidal cleavage of that mineral but is observed in twins according to the face of (101). When suitable material is available for study it will be interesting to see whether relations between the lengths of the crystallographical axes and the proportions

*l. c., p. 135.

of its constituent elements, can be discovered, as has been done in the case of the minerals of the humite group.

Goldschmidtite Au_2AgTe_6	Sylvanite $AuAgTe_4$.
Monoclinic	Monoclinic
$\beta = 89° 11'$	$\beta = 89° 35'$
$a : b : c$	$a : b : c$
1·8562 : 1 : 1·2981	1·6339 : 1 : 1·1265
Perfect cleavage (010)	Perfect cleavage (010)
Common twinning plane (100)	Common twinning plane (101)
Columnar axis, c	Columnar axis parallel to (101)

	Angles.	Angles.	Diff.
$a : m$	61° 41′	58° 32′	+3° 9′
$b : m$	28 18	31 28	−3 10
$f : a$	42 42	39 15	+3 27
$s : a$	54 57	54 57	
S : a	55 35	54 52	+ 43
$n : a$	34 13	35 48	−1 35
$n : s$	20 43	19 9	+1 34
a : N	34 58	35 16	— 18
$c : a$	89 25	89 35	— 10
S : N	20 37	19 36	+1 1

Conclusions.

1. Goldschmidtite is a new mineral species of composition represented by the formula Au_2AgTe_6.

2. It occupies an intermediate position exactly half way between calaverite and sylvanite.

3. Calaverite, Goldschmidtite, and sylvanite form together an homologous series, analogous to that of the minerals in the humite group, the common difference being the addition of Ag_2Te and the subtraction of $Au\frac{5}{3}$ in passing from any one of the series to the next above it.

4. Goldschmidtite has monoclinic symmetry with β 89° 11′, and $a : b : c$, 1·8562 : 1 : 1·2981. It exhibits no less than twenty-two crystal forms, most of which are in the zones of c and $\bar{b}$.

5. Crystallographically as well as chemically Goldschmidtite shows affinities with sylvanite, ten forms being common to the two minerals, though they are referred to axial unities of which $\dot{a}$ and $\dot{c}$ are each about one-seventh longer in Goldschmidtite than in sylvanite.

University of Wisconsin.

ART. XL.—*On a Hydromica from New Jersey;* by F. W. CLARKE and N. H. DARTON.

WHILE studying the Jura-trias formation in New Jersey, one of us (Darton) found in an old "trap" quarry at Rocky Hill a hydromica, which occurred under such novel conditions that it appeared to be worthy of investigation. It is found in veins of calcite, mainly as a thin coating, and adjacent to the diabase of the vein walls. The latter consist of more or less decomposed rock, of which the principal product is a soft, dark-green chloritic material. In portions of the vein the mica extends down the cleavage planes into the masses of calcite. A considerable amount of the calcite was thrown out during the quarrying operations, but only a portion of it is covered with the mica. This portion presents the appearance of having been coated with bronze paint.

The mica occurs in minute flakes thinly matted together. Its color is golden bronze, although some portions are slightly greenish. The mineral is soft, and thinly foliated. Under the microscope it exhibits no definite crystalline form; and its optical properties, although not distinctive, suggest biotite. It appears to be biaxial, but with a very small axial angle, and it is pleochroic. When heated, it does not exfoliate. It fuses before the blowpipe, at a moderately high temperature, to a dark colored bead. The specific gravity was not determined. It is readily decomposable by hydrochloric acid. The analysis, by Mr. George Steiger, of material not free from calcite, is subjoined. In the second column of figures the *reduced* analysis is given, titanic oxide and calcite being thrown out, soda recalculated to terms of potash, and the whole adjusted to 100 per cent.

	Found.	Reduced.	Ratios.
SiO_2	32·72	40·24	·671
TiO_2	·24	----	----
Al_2O_3	8·41	10·34	·101
Fe_2O_3	19·99	24·57	·154
FeO	4·24	5·21	·072
CaO	10·30	----	----
MgO	5·51	6·78	·166
K_2O	·85	2·20	·024
Na_2O	·63	----	----
CO_2	8·21	----	----
H_2O at 100°	2·47	3·03	·168
H_2O above 100°	6·22	7·63	·424
	99·79	100·00	

This gives, as an orthosilicate, the formula

$$(KH)_{68}(MgFe)_{34}(AlFe)_{51}(SiO_4)_{67}.\quad 28H_2O.$$

It is evident, from these data, that the mica is one which has been largely, but not wholly, altered to a vermiculite; the latter term indicating a mica in which potassium has been replaced by hydrogen, and which has taken up water of crystallization. So far as the analysis goes, the condition of the water is uncertain; for it was determined in two fractions only, at and above 100°, whereas more fractions are needed for accurate diagnosis. Some crystalline water may be retained far above 100°, so that the loss above that temperature includes part of this fraction plus all the water of constitution. Apart from this uncertainty the ratios reduce easily in terms of the mica theory to the following molecular mixture:

$$3\begin{matrix}\diagup SiO_4 = KH_2\\ Al—SiO_4 = Al\\ \diagdown SiO_4 = Al\end{matrix} + 6R'''\begin{matrix}\diagup SiO_4 = H_2\\ —SiO_4 = R'''\\ \diagdown SiO_4 = R'''\end{matrix} + 5R'''\begin{matrix}\diagup SiO_4 = R''H\\ —SiO_4 = R''H\\ \diagdown SiO_4 = R''H\end{matrix} 3\text{ aq.}$$

Calculating with the atomic ratios $Al : Fe''' :: 2 : 3$, and $Fe'' : Mg :: 3 : 7$, we have the following comparison between analysis and theory:

	Reduced.		Calculated.
SiO_2	40·24		40·55
Al_2O_3	10·34		10·51
Fe_2O_3	24·57		24·71
FeO	5·21		5·21
MgO	6·78		6·75
K_2O	2·20		2·27
H_2O, 100°	3·03	Crystalline	4·34
H_2O above 100°	7·63	Constitutional	5·66
	100·00		100·00

In short, the mica consists of muscovitic and phlogopitic molecules in the ratio of 9 : 5.

$$9R'''_3(SiO_4)_3R'_2,$$
$$5R'''(SiO_4)_3R''_2H_2,\ 3\text{ aq.}$$

The mineral is evidently an unusual mica, differing widely from any other hitherto described. Its very high proportion of ferric oxide is its chief characteristic, and suggests a ferric muscovite as one of the antecedent, unaltered molecules. Such a muscovite is theoretically conceivable, but is not actually known.

Laboratory U. S. Geological Survey, Feb. 18, 1899.

Art. XLI.—*Powellite Crystals from Michigan;* by Charles Palache.

Powellite was first described by Melville* from a specimen from the "Seven Devils" Mountains, Idaho, where it occurred associated with copper ores and garnet. This material was well crystallized and Melville was able to establish its tetragonal character and the forms $c(001)$, $p(111)$, and $e(101)$. The isomorphism with the scheelite group suggested by the close agreement between the axial ratio and angles of powellite and scheelite was not fully shown, though the author says: "Small rudimentary planes appear on some crystals at the lower portion of the combination edges (111) (101), thus suggesting hemihedrism as in scheelite. Indeed the curved surface which often replaces these edges, giving the appearance of fused edges, adds greatly to the evidence in favor of this supposition."

A second occurrence of powellite, in the South Hecla Copper Mine, Houghton County, Michigan, was described by Koenig and Hubbard.† Their material was poorly crystallized and added nothing to our crystallographic knowledge of the mineral. It differed from the Idaho mineral in its paragenesis, occurring with native copper and epidote, and in its composition, having only about $1\frac{1}{2}$ per cent of its molybdic acid replaced by tungstic acid, as against about 10 per cent in the first occurrence.

Powellite continues to be found at the Michigan locality, though in small quantities and for the most part in massive form. Through the kindness of Mr. John T. Reader, of Calumet, through Dr. L. L. Hubbard, two particularly fine crystals came into the writer's hands and their description follows.

Both crystals are removed from the matrix upon which they grew. They are perfectly free from impurity of any sort and the specific gravity of the larger one could be determined with accuracy by weighing on the hydrostatic balance. Two determinations gave 4·358 and 4·353.

The crystals are pale bluish green in color, translucent, with subadamantine luster on the crystal faces and a greasy luster on fracture surfaces.

The larger of the two crystals is a centimeter in height and has one end complete, but the faces are somewhat uneven; the smaller one is half a centimeter in height and diameter and has both ends developed though neither is quite complete. The

* This Journal, vol. xli, 1891, p. 138.
† This Journal, vol. xlvi, 1893, p. 356.

quality of its faces is sufficiently good to insure accurate measurements.

The measurements were made on a two-circle goniometer (Goldschmidt model) and the observed angles therefore appear in the form of the angular coördinates, ϕ and ρ, as used in the Winkeltabelle of Goldschmidt.

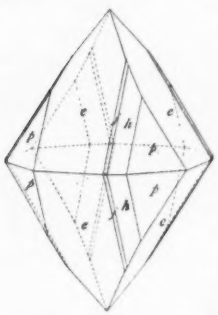
The forms observed were:

$p(111)$ $e(101)$ $h(133)$ $j(3{\cdot}11{\cdot}11)$ $k(155)$ $l(1{\cdot}11{\cdot}11)$.

and the following table shows the observed and calculated angles.

	Symbol.		Observed angle.		Calculated angle.		
Letter.	Miller.	Gold't.	ϕ	ρ	ϕ	ρ	No. of times observed.
e	011	01	00° 00′	57° 04⅔′	00° 00′	57° 00′	3
p	111	1	44 59	65 24	45 00	65 24	2
h	133	⅓1	18 28	58 25½	18 26	58 26	2
j	3·11·11	$\frac{3}{11}$1	15 08	58 00	15 15	58 00	3
k	155	⅕1	11 19	57 38	11 18	57 35	1
l	1·11·11	$\frac{1}{11}$1	5 11	57 08	5 11	57 11	1

As shown by the accompanying figure, the pyramidal hemihedrism is strongly emphasized by the faces of $h(133)$ and $j(3{\cdot}11{\cdot}11)$, the first especially being broad and of perfect quality. The other two hemihedral forms, $k(155)$ and $(1{\cdot}11{\cdot}11)$ were very narrow faces in the zone, and as they were each observed but once they must be considered as doubtful and were therefore not introduced into the figure. There is a tendency for these planes to form a striated or curved surface between the forms p and e such as Melville observed, but there were two zones on the crystal in which the faces were sharply enough bounded to give good measurements.



The measurements lead to the same axial ratio as those made by Melville and the isomorphism of the species with the scheelite group is thoroughly established.

With the crystals of powellite sent by Dr. Hubbard was another specimen of the mineral of quite a different appearance. It consists of a rounded mass of powellite about two centimeters in diameter, upon which are a few small fragments of rocky matrix, minute crystals of bright green epidote and two or three shreds of native copper. On the broken surfaces the powellite shows an imperfect cleavage, seemingly parallel to $e(101)$. The central part of the specimen is of the same

bluish-green color as the crystals, but the surface layer to the depth of about three millimeters appears quite black and opaque in reflected light and when examined in thin splinters is seen to be colored a deep prussian blue. The boundary between the two colors is not sharp but the darker portion shades off rapidly into the lighter part.

The dark-colored material is crystallized in a number of small individuals, all in parallel position and showing approximately the same forms as the crystals before described but with greater proportional development of the forms *e* and *h*.

An attempt was made to separate some of the darker material for chemical examination, it being assumed that the lighter colored part did not differ from the similar material analyzed by Koenig and Hubbard; but it proved impossible to obtain a sufficient amount for any satisfactory tests. A small amount (·051 gram) was however picked out in which there was a very slight admixture of light-colored substance and a few minute grains of epidote, and its specific gravity was determined to be 4·214. This determination is not wholly reliable on account of the impurities and the small amount of material, and it is probably too low; but it seems to the writer fairly certain that the specific gravity of the dark material is less than that of the light (4·355). The specific gravity of the pure calcium molybdate has been calculated to be 4·267 (Melville), a value which is rapidly raised by even small quantities of the tungstate. It seems probable, in view of these facts, that the dark blue material represents an occurrence of almost pure calcium molybdate. It is much to be hoped that more material will be found which will permit the chemical proof of the existence of this end member of the scheelite-powellite series.

Mineralogical Laboratory,
Harvard University, February, 1899.

ART. XLII.—*The Volatilization of the Iron Chlorides in Analysis, and the Separation of the Oxides of Iron and Aluminum;* by F. A. GOOCH and FRANKE STUART HAVENS.

[Contributions from the Kent Chemical Laboratory of Yale University—LXXXI.]

IT is well known that metallic iron is easily acted upon by an excess of chlorine at moderately elevated temperatures with the formation of ferric chloride, and that the product of the action of hydrochloric acid gas upon the metal is ferrous chloride. Out of contact with air, or moisture, both chlorides may be volatilized at appropriate temperatures—the ferric chloride below 200° C.; the ferrous chloride at a bright red heat. If water vapor, or oxygen, or air be present during the heating, both chlorides are partially decomposed with the formation of non-volatile residues, ferric oxide or ferric oxychloride.

Analytical processes involving the volatilization of iron at temperatures more or less elevated, in an atmosphere of chlorine or hydrochloric acid, have been the object of considerable attention. Thus, Fresenius,* Drown and Shimer,† and Watts,‡ have heated crude iron in chlorine to remove the metal and leave the non-volatile constituents; and Sainte-Claire Deville§ has employed hydrochloric acid to volatilize iron from mixtures of that metal with alumina (obtained by heating the mixed oxides of iron and aluminum in hydrogen according to Rivot),‖ exposing the mixture, contained in a porcelain boat and placed within a porcelain tube, to the bright red heat of a charcoal furnace—an operation which was bettered by Cooke's¶ use of a tube of platinum instead of the porcelain tube and a gas blowpipe in place of the charcoal furnace. Sainte-Claire Deville** showed, further, that ferric oxide may be converted to ferric chloride and volatilized at the heat of the charcoal furnace if the current of hydrochloric acid is sufficiently rapid; but the curious effect was observed that in a sufficiently limited current of the acid no chloride whatever was volatilized, while the amorphous oxide was converted to the highly crystalline oxide of the same composition—a phenomenon which gave rise to a theory of the natural formation of specular iron in volcanic regions.

Quite recently, Moyer†† has made record of an unsuccessful attempt (in the course of experimentation upon the volatility

* Zeitschr. für Anal. Chem., iv, 72. †Jour. Inst. Min. Eng., viii, 513.
‡ Chem. News, xlv, 279. § Ann. de Chim. et de Phys. [3], xxxviii, 23.
‖ Ann. de Chim et de Phys. [3], xxx, 188. ¶ This Journal [2], xlii, 78.
** Compt. Rend., lii, 1264. †† Jour. Amer. Chem. Soc., xviii, 1029.

of certain chlorides at comparatively low temperatures) to convert ferric oxide completely to ferric chloride by the action of gaseous hydrochloric acid at about 200° C. At this temperature the greater part of the iron sublimed, but a residue remained, which, volatilizing neither on long heating at 200° nor upon considerable elevation of the temperature, proved upon examination to be ferrous chloride. In the experiments to be described we have acted with gaseous hydrochloric acid upon ferric oxide made by igniting the nitrate prepared from pure iron deposited electrolytically by high currents passing between electrodes of platinum in a strong solution of ammonio-ferrous sulphate. The oxide, contained in a porcelain boat, was heated within a roomy glass tube over a small combustion furnace. The hydrochloric acid (generated by dropping sulphuric acid into a mixture of strong hydrochloric acid and salt, and dried by calcium chloride) entered one end of the tube and passed out at the other through a water trap. In early experiments a high-reading thermometer was inserted through the stopper in the exit end of the tube so that its bulb was above and immediately adjacent to the boat carrying the oxide. In this way the actual temperatures of the vapors about the boat were fixed with considerable accuracy; later, after a little experience in gauging the effect of the burners, it was found that the temperatures could be regulated very closely without actually depending upon the thermometer. We found, as did Moyer, that ferric oxide, submitted to the action of dry hydrochloric acid gas, volatilizes partially as ferric chloride at low temperatures—180° to 200° C.—leaving ultimately a crystalline residue which does not change visibly when heated for an hour or two at 200°, or even at 500°, in the pure dry acid. According to our experience, this residue is generally slightly reddish or salmon-colored; but sometimes, especially after a second heating, the boat having been withdrawn from the tube or exposed to the atmosphere (and so to moisture), the residue is white. When it is white it dissolves in water, yields the characteristic reaction for a ferrous salt with potassium ferricyanide, gives no reaction with potassium sulphocyanide, and upon treatment in weighed amount with potassium permanganate destroys the amount of that reagent theoretically required for its oxidation upon the supposition that it is ferrous chloride. The slightly colored residue when treated with water yields a solution showing the reaction of a ferrous salt only, but when treated with hydrochloric acid and then tested shows the presence of a trace of iron in the ferric condition. Doubtless the coloration of the residue is due to an included trace of ferric oxide or oxychloride, which after exposure of the containing crystals to slight atmospheric action, is more

easily reached in the second heating by the gaseous acid. The amount of residue is somewhat variable, but approximates under the conditions of our work to from five to ten per cent of the oxide taken: thus, in one typical experiment 0·1 grm. of ferric oxide left a residue which (withdrawn after cooling) weighed 0·0115 grm.

The greater portion of the ferric oxide volatilizes when submitted to the action of the gaseous acid at 200° quickly and abundantly in the form of the greenish vapor of ferric chloride, and if the operation is interrupted at this stage the residue which remains is nearly black, insoluble in water, slightly soluble in cold hydrochloric acid, and readily soluble in hot hydrochloric acid with the formation of ferric chloride. It is probably something analogous to the oxychloride which Rousseau* identifies as the product of the action of water upon ferric chloride at 275° to 300°. This dark residue yields to the action of the hydrochloric acid at 180° to 200° only slowly, but ultimately only the residue which is essentially ferrous chloride remains; thereafter little volatilization occurs within the range of temperature of our experimentation—200° to 500°.

It is obvious that a reduction of iron in the ferric condition to iron in the ferrous condition takes place under the conditions of our work, and it is difficult to see how this can occur otherwise than by the direct dissociation of ferric chloride under the low partial pressure conditioned by the brisk current of hydrochloric acid gas. The temperature of formation, 180° to 200°, is far below that at which such dissociation is supposed to begin. Thus, Gruenewald and Meyer† found, after cooling, no evidence of the dissociation of ferric chloride which had been heated in the Victor Meyer vapor-density apparatus to 448° in contact or partial mixture with nitrogen; but ten per cent of the residue obtained by heating to 518° was in the ferrous condition. Friedel and Crafts,‡ however, did see crystals of ferrous chloride at 440° on the walls of a Dumas container filled with the vapor of ferric chloride and nitrogen, the former exerting a partial pressure of 0·75; while ferric chloride volatilized into an atmosphere of chlorine without evidence of dissociation. It seems rather surprising, therefore, to find so large a percentage of dissociation as that shown in our experiments at a temperature so low—180° to 200°. Curiously, too, we find, on repeating the experiment of heating ferric oxide in gaseous hydrochloric acid, that if the temperature of the oxide is 450° to 500° when the brisk current of acid begins to act, the whole mass of oxide is converted and volatilizes without resi-

* Compt. Rend., cxvi, 118. † Ber. d. d. Chem. Gesell., xxi, 687.
‡ Compt. Rend., cvii, 301.

due. It is hardly to be supposed that the degree of dissociation at 450° to 500° can be less than that at 180° to 200°, and a test of the sublimate, after cooling, shows that it contains a ferrous salt. Plainly, ferrous chloride (formed by dissociation) has volatilized, and inasmuch as the ferrous chloride constituting the residue formed at 180° to 200° does not volatilize in the hydrochloric acid even at 500°, it is plain that the volatility of the former is not determined by the presence of the latter. Apparently, the cause of the completeness of volatilization must be sought in its rapidity; and this is not an unreasonable hypothesis, if one considers that an action sufficiently rapid to keep above the boat an atmosphere of ferric chloride and its products of partial dissociation, might naturally provide the very condition which would be effective in counteracting the tendency of the residue to dissociate before it volatilizes. If this hypothesis is correct, it is plain that the introduction of chlorine gas, the active product of dissociation, into the atmosphere of hydrochloric acid ought to bring about the volatilization of the residue of ferrous chloride, formed at 180° to 200°, which refuses to volatilize in the acid alone. As a matter of fact, we find by experiment that if a little manganese dioxide is added to the contents of the generator, so that the hydrochloric acid may carry with it a little chlorine, every trace of ferric oxide is volatilized from the boat at 180° to 200°; and the residue of ferrous chloride found at 180° to 200° when the hydrochloric acid is used alone is likewise volatilized at the same temperature, when the admixture of chlorine is made.

These facts, that ferric oxide is completely volatile in hydrochloric acid gas applied at once at a temperature of 450° to 500° C., and at 180° to 200° if the acid carries a little chlorine, open the way to many analytical separations of iron from substances not volatile under these conditions. In the experiments of the following table we have applied these methods to the separation of intermixed iron and aluminum oxides. The ferric oxide employed was made, as before, by ignition of the nitrate prepared from iron deposited electrolytically by a strong current passing between platinum electrodes in a solution of ammonio-ferrous sulphate.* The aluminum oxide was made by igniting to a constant weight the carefully washed hydroxide precipitated by ammonia from a pure hydrous chloride thrown down from the solution of a commercially pure chloride by hydrochloric acid.† The hydrochloric acid

* The use of an anode of commercially pure iron wire naturally facilitates the operation, but in our experience the deposit thus obtained is likely to carry traces of impurity. In an attempt, too, to prepare pure ferric oxide from the oxalate thrown down out of ferrous sulphate with all precautions, the material obtained still held traces of silica, and possibly alumina, amounting to 0·0004 grm. in 0·1 grm. of the oxide.

† This Journal, II, 346.

gas was made by dropping sulphuric acid into strong hydrochloric acid mixed with salt, and a little manganese dioxide was added when the mixture with chlorine was desired. The experimental details are given in the table.

Fe_2O_3 taken. grm.	Al_2O_3 taken. grm.	Al_2O_3 found. grm.	Error. grm.	Time. hours.	Temperature. C°.	Atmosphere.
0·1000	----	----	0·0000	½	450–500	HCl.
0·2000	----	----	0·0000	1	"	"
0·1020	0·1015	0·1015	0·0000	½	"	"
0·2145	0·1006	0·1008	+0·0002	¾	"	"
0·1000	----	----	0·0000	¾	180–200°	$HCl+Cl_2$.
0·1000	0·1032	0·1032	0·0000	¾	"	"
0·1072	0·1013	0·1015	+0·0002	1	"	"
0·2045	0·1032	0·1033	+0·0001	1¼	"	"
0·1050	0·1023	0·1019	−0·0004	½	450–500	"
0·2008	0·1007	0·1006	−0·0001	¾	"	"
----	0·1087	0·1087	0·0000	1	"	"

The residual alumina tested in several experiments by fusion with sodium carbonate, solution in hydrochloric acid, and addition of potassium sulphocyanide gave no indication of the presence of iron.

The separation of the iron is obviously complete at 450° to 500° when the mixed oxides are submitted at once to the action of hydrochloric acid gas, or at 180° to 200° when chlorine is mixed with the hydrochloric acid. Plainly, the extremely high temperatures employed by Deville are unnecessary if the mixed oxides are submitted at once to the action of hydrochloric acid at 450° to 500° without previous gentle heating in the acid atmosphere. We prefer, however, to use the mixture of chlorine and hydrochloric acid, not only because the temperature of the reaction is lower, but because it needs no regulation, while the danger of error arising from the liability of ferric chloride to dissociate, or from deficiency of oxidation in the oxide treated, or from mechanical loss due to too rapid volatilization, is avoided.

ART. XLIII.—*Descriptions of imperfectly known and new Actinians, with critical notes on other species*, V; by A. E. VERRILL. *Brief Contributions to Zoology from the Museum of Yale College*, No. LXII.

Family BUNODACTIDÆ. (Continued from p. 218.)

Bunodactis inornata Verrill. Figure 39.

Actinia inornata Stimpson, 1855.
Bunodes inornata Verrill, Proc. Essex Inst. Salem, Mass., vol. vi, p. 61, [27], 1869, pl. i, fig. 5.

THE type of this species is still preserved, though it has at some former period been partly dried, and is, therefore, much contracted, in a hemispherical shape. The tentacles are wholly retracted. The upper part of the wall is closely covered with rather large concave suckers, but they rather suddenly diminish in size and become confused with the deep, vermiculate, wrinkles on the lower half of the column, though some persist to near the base.

In section, there are 24 pairs of larger complete mesenteries, including two pairs of directives. Alternating regularly with these there are 24 pairs of smaller mesenteries, most of which are incomplete, but are well developed, with a small but prominent muscular pennon near the distal end, occupying a quarter or less of the breadth. The larger mesenteries have strong median muscular pennons, occupying about a third of their breadth. All, or nearly all, the septa bear large gonads. The tentacles, in transverse sections, show a stellate muscular layer, due to the strong radial supports.

The sphincter muscle is large, clearly defined, nearly circular in section.

Hong Kong, at low water mark, in gravel.—Dr. Wm. Stimpson.

Some Actinians that incubate their eggs externally.

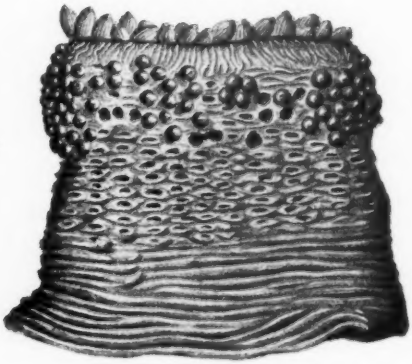
The next four species, described below, are remarkable for the habit of carrying their relatively large eggs attached to the body in special pits, where they are retained until hatched and provided with tentacles. In these cases the egg develops directly into an actinula. This habit was described by me in 1869 as occurring in two of these species, but it has not attracted the attention of others to any great extent. I am now able to add two other species, of large size, having the same habit in a still more striking degree. They belong to the *Bunodactidæ*, but differ considerably in generic characters.

Pseudophellia, gen. nov. Type, *P. arctica* Ver.

Column much elongated, covered with an adherent cuticle, much as in *Phellia*, except near the summit. When the cuticle is removed the surface is finely papillose and wrinkled, in alcohol. Below the middle there are several transverse rows of large pits for carrying eggs. These are deeply excavated in

34.

35.



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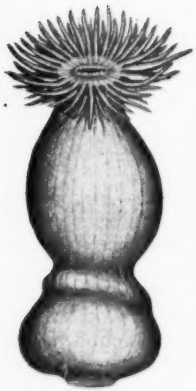


36.

the wall by a thinning of the mesoglœa. Capitulum smooth Wall thick and firm. Sphincter muscle well developed, circumscribed. Mesenteries form about 24 perfect pairs with a few imperfect ones. Two siphonoglyphs and two pairs of directives in the type. Tentacles tapered, in two or more rows.

***Pseudophellia arctica* Ver. Figure 34 (type).**

Phellia arctica Verrill, Proc. Essex Inst., vol. v, p. 328 [14], 1868; Trans. Conn. Acad., i, p 490, 1869 (*not* of Danielssen*).

The type of this species is still preserved. The original description is pretty complete as to the external appearance, but a typographical error occurred, in the measurement of the eggs. They are ·05 of an inch in diameter (not ·5). When I originally described them I did not feel certain that they were not parasitic structures, but subsequent discoveries have removed this doubt. The mouth has two strong siphonoglyphs and about 18 folds on each side. The stomodæum is strongly plicated. There are about 24 nearly equal pairs of perfect mesenteries, with a few small ones of the fourth cycle. The longitudinal muscles are rather thick and strong on the perfect mesenteries.

The tentacles are rather large and moderately long; they are only partly retracted in the type, but the sphincter muscle is well developed, so that they are probably capable of complete retraction and concealment. In section the sphincter muscle has an ovate outline. The wall is rather thick and firm with a thick mesoglœa, except in the capitulum, which is smooth externally and forms a distinct submarginal fold and small fosse. Circular muscular layer of the wall is well developed. The cuticular layer is thick and soft, and often nearly or quite conceals the eggs when enclosed in the pits, which are largely excavated in the mesoglœa.

***Epiactis prolifera* Ver. Figure 25.**

Trans. Conn. Acad. i, p. 492, 1869.
Epiactis fertilis Andres, op cit., p. 363, 1884.†

The figures now given are from one of the original types.

The largest specimens seen have about 96 tapered tentacles; they can be entirely retracted and concealed.

The wall, in section, is moderately thick and firm, with the different layers very distinct; the ectoderm is rather thick and close; muscular layer well defined and continuous. The sphincter muscle is large, clearly circumscribed, ovate in section, essentially endodermal, but not so much detached from the wall as usual in *Bunodactidæ*. There is a distinct collar and fosse, in contraction. The mesenteries are regularly hexamerous, in four cycles, with some small ones of the fifth; 12 or

* The *Phellia arctica* Dan. (Actinida, p. 54, 1870) is a true *Phellia* and may be called *P. Danielsseni*, to avoid confusion with our species.

† Andres changed the specific name on account of its prior use for *Gonactinia prolifera* Sars, but that belongs not only to a different genus, but to a widely different family, so that the change of name was not necessary.

more pairs are perfect and fertile. Their longitudinal muscles are not very thick, but cover most of their breadth.

The stomodæum is strongly plicated and has two large siphonoglyphs. The ovaries, in some cases, contain large eggs, like those carried on the outside. The egg-pits are not so deep as in the preceding three species and at first they are confined to the ectoderm, but as the embryos develop the pits become larger and deeper, partly by a slight invection of the wall and partly by a thinning of the ectoderm and mesoglœa so that at length they may be as deep as half the thickness of the wall, but they never become like the deep pits of the preceding two genera. No acontia could be found.

This genus resembles, in some respects, the *Paractidæ*, but it seems to belong to the *Bunodactidæ*, on account of the sharply circumscribed sphincter muscle, although the latter is not so much separated from the inner layers of the wall as usual in that family.

Epigonactis, gen. nov.

Large stout Bunodactidæ, with numerous large egg-pits on the upper half of the column, arranged in more or less regular rows and often crowded on the upper part, below the collar. These pits, when fully formed, are deeply excavated in the thick mesoglœa and when containing eggs some of the latter may be nearly or quite covered and concealed by the tissues growing around them. In contraction there is a well-developed fold or collar covered with numerous longitudinal grooves, but without verrucæ; fosse smooth. Tentacles numerous, large, rather long, sulcated in contraction. Sphincter muscle large, circumscribed. Perfect mesenteries numerous and fertile. Eggs large. Wall firm and thick, in sections the layers are very distinct; the circular muscular layer shows, in alcohol, as a well-defined, continuous, brownish yellow layer; mesoglœa thick.

Epigonactis fecunda, sp. nov. Figure 35.

Body nearly cylindrical, about as high as broad in contraction; base muscular and strongly adherent, not much wider than the column, or even narrower in one example in alcohol. Tentacles, in the smaller specimen, 72, stout, blunt, some of them rather long, others contracted so that they are only little longer than thick; they are retracted in most cases so that their tips project but little beyond the marginal collar but are not infolded; some of them appear to be perforated at tip, and most are sulcated by contraction. They are arranged in two or three marginal rows. Collar large and prominent, much thickened, but without marginal tubercles; fosse deep, with a

nearly smooth surface. Outside of collar and upper parts of column below it are covered with intricate wrinkles and irregular vermiculate elevations, which surround and enclose numerous deep round pits, mostly closely crowded together. In most of the pits there is a large spherical egg, about 2^{mm} in diameter; most of these project beyond the pits, but some are entirely concealed in the thickened integument.

The egg-bearing pits are most numerous within 12 to 15^{mm} of the collar margin, but some occur lower down. They form a conspicuous zone all around the body, in which the eggs are so crowded as to be in contact in the alcoholic specimens. They adhere firmly. Lower down on the column there are sucker-like pits in vertical rows, decreasing in size downward and mostly disappearing near the middle. They are obscured by the wrinkled surface, but become very evident where the soft wrinkled ectoderm is rubbed off.

In vertical section the wall is moderately thick and very firm both in base and column, plicated by wrinkles; the layers are easily visible with the naked eye, both in base and column; the circular muscular layer shows as a continuous yellow line. The mesoglœa is variable in thickness, being thickened near the base and in the basal disk, but especially so at and below the collar, where the egg-pits occur; in this region it is very much thickened around and between the pits, but is very thin under them, so that it is very irregular and much lobulated; above the collar it is thin. The sphincter muscle is large, round or ovate in section, circumscribed and pedicellate. The mesenteries form about 36 pairs, of which 24 or more are perfect, but they are irregularly developed in the different sextants. In one case six fully developed and nearly equal pairs occur on one side of a pair of directives, while on the other side those of the fourth and fifth cycles are much smaller than the rest. The perfect pairs and most of the others bear large and broad longitudinal muscles, which are thick and strongly plicated. All or nearly all the mesenteries bear large gonads, which are so densely crowded together, in the specimen dissected, that it is not possible to separate them, or place them accurately. They contain numerous large ova similar in size and appearance to those on the exterior of the body. Color not recorded.

Height, in alcohol, about 2·25 inches (56^{mm}); diameter 2·5 inches (62^{mm}).

East of Banquereau, off Nova Scotia, 150 fathoms, Sch. "Polar Wave," lot 37, 1878, 1 specimen; off Nova Scotia, 200 fathoms, Capt. John Rowe, lot 35, 1 specimen.

Epigonactis regularis, sp. nov. Figure 36.

Body, as contracted in alcohol, nearly hemispherical, with the base as wide as any part. Disk and tentacles concealed. Wall firm and elastic, covered with a yellowish brown ectoderm; not much wrinkled, except near base and on collar. The collar is strong and sulcated, and also finely wrinkled transversely, giving the surface an areolated appearance. Near the base the wrinkles are transverse and wavy. On the upper half of the column there are vertical rows of large egg-pits, some of them circular and cup-shaped, others oval or egg-shaped; some of them are bordered by several small convergent lobes, others with folds, while some are widely open. They carry no eggs in the type, but are evidently used for that purpose. The wall is thickened at the collar, but thin above it; lower down it is of moderate thickness but firm; the three layers are very definite and easily visible to the naked eye, in sections, without staining; the sphincter is large, elliptical in section, well circumscribed. The circular muscle layer is continuous and well-defined.

Tentacles about 90, stout, sulcated, rather obtuse, of moderate length, arranged in three or four crowded rows; mouth large, with two siphonoglyphs, bordered by large lobes.

Mesenteries form about 44 pairs, most of which are perfect and bear gonads. In a section, near the lower part of the stomodæum, 36 perfect pairs were counted, and most of the remaining eight, which were nearly as wide, may be attached lower down. Those next to the two pairs of directives, on each side, were the least developed. Owing to the equality in the size of the mesenteries no definite hexamerous arrangement could be made out. The longitudinal muscles are very broad, covering nearly the whole breadth of the mesenteries, thick and pleated; those of the directives are less thick, but have a second inner enlargement, near the siphonoglyphs. There are no rudimentary or narrow mesenteries between the larger ones in the gastric region.

Fishing Banks, off Newfoundland, in deep water. It was brought up on the trawl hooks of a Gloucester, Mass. fishing vessel, but no record of the precise locality was given.

ART. XLIV.—*A Preliminary Note as to the Cause of Root-Pressure;* by ROBERT G. LEAVITT.

THE following suggestion is made in the hope of breaking a way toward the proper understanding of the nature of so-called root-pressure. The hypothesis here tentatively proposed seems to coördinate certain of the results obtained by Sachs, Clark and others, which after several years still stand in apparent need of explanation.

Van 't Hoff's interpretation of the exact determinations of osmotic pressures made by Pfeffer, de Vries, Tammann and others, which interpretation is generally accepted by physicists and by Pfeffer himself, though still neglected by the majority of writers on vegetable physiology, is here assumed as the basis of the discussion on the physical side. Unfamiliarity with this theory on the part of many botanists may warrant a condensed statement of its central principles.

Solutions (the term being applied to the dissolved substances, exclusive of the solvents) act in all ways, both qualitatively and quantitatively, as gases, exerting pressure against containing water-, or other, surfaces by an inherent expansive force. The laws of solutions are identical in form, if "solution" be substituted for "body of gas," with the laws of Boyle, Charles and Avogadro for gases. Quantitatively considered, "dissolved substances exert the same pressure, in the form of osmotic pressure, as they would exert were they gasified, at the same temperature, without change of volume."

The distention of a turgid cell is then due to the pressure of organic matters in the cell sap, unable to escape or able to escape only with difficulty. The entrance of water is a consequence, not cause, of the osmotic pressure. A sufficient supply of water at hand is, to be sure, a necessary condition for allowing the osmotic force to act and push the cell-wall outwards, since the boundaries of the solvent, equally with definite membranes, limit the molecular wandering of the solution.

The movement of water up the stem of the thistle-tube, in the familiar experiment, is caused by the upward pressure of the solution against the free surface of the water; the water and the membrane below both being passive accessories in the operation. If the stem were crossed by diaphragms permeable by both water and solution, these would not constitute osmotic membranes in the sense of occasioning osmotic stress and flow of water; osmose and filtration of water would proceed through them. If the stem, however, were crossed by a membrane permeable by water but not by the solution, both would be stopped, and no exfiltration of the water by action of the confined osmotic substance is conceivable.

Osmose being defined as the diffusion of a solution through a membrane, and water being in no sense a solution, "endosmose of water" is mistaken phraseology. Some other appropriate term should be employed, such as infiltration. "Osmotic pressure" is unmistakable, but it is well to keep in mind that pressure arises through failure of the solution to accomplish osmose.

Coming now to the plant-body as an osmotic machine, we may distinguish two categories of osmotic pressures with their consequent filtrations of water, according as (1) the solutions are confined within single (living) cells, or (2) the osmotic substances permeate the whole cellular system from root-tip to leaf. The first may be termed localized or intracellular osmotic pressure, the second general internal, or sap-pressure.

The difficulties involved in ascribing root-pressure to localized osmotic action of the root parenchyma are well understood, and need not be dwelt upon. Some of them seem to be obviated by attributing the phenomenon in question to general internal osmotic pressure. The root immersed in the wet soil may be compared to the thistle-tube of the common experiment. The root-surface or surface tissue will then answer to the membrane stretched over the mouth of the tube. Tracheæ, tracheids, intercellular spaces, and all parts dead or alive through which sap-solutions percolate, may answer as a whole to the interior of the thistle-tube. Soil water may correspond to the water in the outer dish and sap with its contents, to water with its salt or sugar inside the thistle tube. The water in the stem of the latter, rising by reason of upward osmotic pressure on its free surface, overflows in an osmotically driven stream. The outflow from the root, when the stem is cut off, may have a like cause. In the artificial apparatus the solution washes out with the stream, and the end of the process ensues. In the case of the living apparatus stores of insoluble organic matters (as starch) are present, from which the reduced fund of osmotic substances (as sugars) may be replenished from time to time by action of enzymes, causing periodic overflows of the kind described by Sachs. The flows would naturally decrease in volume as the stock of reserve materials became gradually exhausted.

The observations of Sachs on the effect of heat in increasing absorption, and of Clark on pressure in tree-trunks, accord well with the supposition that both kinds of phenomena are due to general osmotic sap-pressure.

The agency of osmotic sap-pressure as more or less important among several possible factors in maintaining or restoring the continuity of free water between root and leaf during transpiration, is here suggested. So-called negative pressure may probably be shown to be compatible with a simultaneous osmotic sap-pressure of considerable intensity, when the supply of water at the root falls below the demand.

Harvard University, April 14, 1899.

ART. XLV.—*A Study of Some American Fossil Cycads.** Part III. *The Female Fructification of Cycadeoidea;* by G. R. WIELAND. (With Plates VIII–X.)

Introduction.

FEMALE fruits of fossil Cycads from America have not been hitherto described. European specimens, however, have furnished two nearly perfect examples which have been made the objects of careful research and discussion during the past thirty years. In fact, the study of *Bennettites Gibsonianus* by Carruthers,[3] and Solms-Laubach,[8, 9] together with Lignier's[12] investigation of *Bennettites Morièrie*, may well be considered one of the triumphs of modern paleobotany. As a result, the structure of the cycadeoidean seed-bearing organs is nearly as well known as that of the existing cycads.

The subject of female fructification, as far as treated before the announcement of the discovery of the corresponding male flower in Part I of these contributions, has been amply reviewed by Seward. Hence it is only necessary to state briefly that the object of this preliminary paper is to deal with several quite perfect cycadeoidean fruits as observed in certain trunks from the Jurassic of the Black Hills. These, it will be seen, are in all essential characters similar to the English, French, and Italian examples of *Cycadeoidea*, of which the best known are *Cycadeoidea* (*Williamsonia*) *gigas*, Carruthers, and *C.* (*Bennettites*) *Gibsonianus*, Carr., both from the lower Greensand of the Isle of Wight, *C.* (*Bennettites* and *Williamsonia*) *Morièrie*, Saporta, from the Oxfordian of Normandy, and *C. etrusca*, Capellini and Solms-Laubach, from the Etruscan Necropolis at Marzabotto, the original locality of which is unknown. The American forms are so analogous to the several foregoing species as to preclude more than specific difference, and thus add one more argument in favor of the approximately synchronous existence of these highly specialized forms on both continents. Whether or not final study will permit their retention in a single genus is, however, a doubtful question that need not now be taken up; nor can the subject of the bracts and peduncles be treated in the present paper, although recent studies by Scott[20] make it quite certain that their investigation will furnish valuable data.

* Part I of these studies appeared in this Journal for March of this year, and Part II in the April number following. The numbers refer to the list of papers given at the end of Part I.

The Fruit of Cycadeoidea Wielandi, Ward (MS.). ♀

General Features.—Cycadean trunk No. 77 of the Yale collection, illustrated on Plate VIII, figure 1, is the female type of the foregoing species. It is a finely preserved example, bearing laterally, in addition to ten apparently fresh scars left by the shedding of ripened fruits, forty more or less complete seed-covered fruits, which were mature or nearly so when fossilization began. The shape of these fruits is ovoid, and their average size is from 3·5 to 4^{cm} in length by 2 to 2·5^{cm} in diameter. In both size and form, they resemble the fruit of *Cycadeoidea* (*Bennettites*) *Gibsonianus*, Carr., though the seeds are less elongate in the latter species.

The embryos of the seeds of this trunk prove to be the only important structures not present in unusual clearness of detail. Moreover, this was the first seed-bearing cycad to be described as such from American formations, as well as the one upon which these studies were begun. Hence it is made the first type of female fructification in American cycads, although other more perfect supplementary material has since been studied.

A close examination of the specimens represented in the plate affords interesting facts concerning the fruit-bearing habit of *Cycadeoidea*. In their various stages of growth, maturity, and dehiscence, the fruits are borne on short peduncles approximately of the same length, thus indicating that the mature fruit was not protruded further from the trunk by subsequent growth. Nor does there seem to be any order of maturity from the base to summit of the trunk in either direction.

In several other related trunks most of the fruits have been shed, being represented by scars only; while a few floral axes remain undeveloped or in an atrophied condition. Still other trunks of this and associated species are barren or bear embryonic fruits. The latter condition is of considerable importance, as it will permit a developmental study of the organs. The only general conclusion to be drawn at present, however, is that there was no sharply limited period when these cycads matured their flowers. Apparently there was a progressive maturity of fruits through an entire season, which was followed by several seasons of unfruitfulness.

From the characteristic form and sculpturing of the scars representing the position of the matured fruits, it would seem that the latter were shed by the parent plant with their parts intact and often with few or no accompanying bracts.

Following fructification and the shedding of ripened fruit, there was a closing up of bracts about the receptacle, with

more or less obliteration. The appearance of the fruits as apparently mature on the trunk, and of the scars mentioned above, are fairly well represented in figures 1 and 2, Plate VIII. In all cases where the seeds are exposed the tips of the bracts are necessarily more or less worn or broken away.

The lateral, or proliferous, inflorescence here exhibited is noteworthy. In this respect these specialized culminant fossil types vary from all the higher existing forms which are sympodial, and partially agree with the genus *Cycas*. The latter is the most primitive living form, and has its peduncles distributed between the petioles for some distance below the apex of the trunk. Among the various species represented in the Yale collection there are none showing the sympodial type and but few flower-bearing examples which have no flowers on the lower half of the trunk, though the male trunks incline to bear the most of their flowers near the summit.

Special Organs.—As stated above, these fruits are ovoid bodies borne on short peduncles. The latter take their origin on the trunk after the manner of the petioles and terminate in an elongated receptacle. This bears laterally an involucre of slender enveloping bracts, and terminates in a "parenchymatous cushion," as termed by Carruthers.[3] The face of this cushion, or secondary receptacle, is flatly convex and bears two series of densely set organs, much modified according to their central or more peripheral position. The first of these are the seed-bearing stems, or essential organs, while the second are merely interstitial and quite analogous to chaff. They are termed "interseminal scales" by Lignier.

The disposition of these parts is illustrated in the longitudinal sections, figures 10 and 12, Plate IX, and in the corresponding transverse sections, figures 9 and 11 of the same plate, as well as in the several transverse sections on Plate X.

In this arrangement of densely set seed-bearing stems and surrounding scales borne on a fleshy bract-enveloped receptacle, there is a certain simulation of the flowers of *Compositæ*.

Histological Structure.

The Parenchymatous Cushion.—This is composed of soft parenchyma centrally, but becomes more dense peripherally. Though no well-marked bundles have been noted, sparse and irregularly branching strands of scalariform cells apparently supply the seed stems. As there is usually a cleavage line, or zone of imperfect preservation, just at their origin, this could not be readily determined. The strands may scatter and end in the cushion. They are illustrated by Carruthers in his description of *Bennettites Gibsonianus*.

Seed Stems.—These are very closely set on the cushion, and as it is difficult to separate their elements from those of the interseminal scales in the longitudinal sections, they may be best studied in transverse sections. Such a section from the middle of the fruit is shown in figures 14 and 16, Plate X, where the stem is seen to consist of a central vascular bundle enclosed in an endodermis which is surrounded by a broad woody outer layer, or xylem zone, the "enveloppe tubuleuse" of Lignier.

Each seed stem is uniformly surrounded by from 5 to 6 interseminal scales. A series of transverse sections from the base to the summit shows no variation from this general arrangement, although there is a slow diminution in the diameter of the stems, accompanied by marked changes in the cell conformation of the xylem zone. In this and other species, there is often at the base a strong compression of the surrounding scales, while the xylem areas are more or less polygonal and composed of cells quite regularly subrhombic in section. Of these, from 30 to 40 may be counted radially, as shown in figure 4, Plate VIII. Towards the summit there is a constant increase in the size and regularity of these cells, which finally become quite round, accompanied by a decrease in the width of the xylem band, until at the base of the seeds it consists of but two layers of cells surrounding the central bundle, which remains constant in character.

This bundle is well illustrated in the enlarged view given in figure 15, Plate X. Centrally there are from 3 to 10 small woody elements. These are enveloped in soft parenchyma, not preserved in all specimens, and the bundle terminates in a well-marked endodermis. Such concentric bundles recall the somewhat similar structures seen in many ferns. The atrophied peduncles, or those lacking a well-marked central bundle, described by Lignier in *C.* (*Bennettites*) *Morièrie*, have not been observed thus far. The interesting case of bifid seed stems, or those with two central bundles within the same tubular, or xylem zone, however, rarely repeats itself in the present specimens.

It may be mentioned that while the figure of the transverse section of the seed stems, "vascular cords," given by Carruthers is a faithful one, its being cut too near the base, where there is much compression of the several elements, prevented a true conception of their significance. Only at some distance above the base does the clear differentiation of parts seen in figure 14, Plate X, appear. Judging from the transverse section by Carruthers, just mentioned, and the additional one given by Solms-Laubach, the tubular layer, or xylem zone, of *C.* (*Bennettites*) *Gibsonianus* was composed of more angular cells than in the case of the present specimen.

Lignier gives a section of a seed stem from near a seed base (peduncle, figure 27, Plate II),[12] in which the tracheidal cord is followed by fundamental tissue, and this by a layer of cells (*assize colorée*), which is in turn surrounded by a single row of cells laterally dovetailing. This alteration at the seed bases has not been observed as yet by the writer, and no doubt must stand as one of the specific variations between the foregoing species.

Interseminal Scales.—Five or six of these commonly surround each seed stem, and rise beyond the seeds, their tips expanding to form the rounded summit of the fruit. Figure 13, Plate X, displays a transverse section of one of these organs cut near its middle height. In the case of cycad No. 77, figure 14, Plate X, the parenchyma surrounding the central vascular strand is not preserved; but the central strand, the large subepidermal cells (much less continuous in this species than in *C. Morièrie*), and the epidermis, are so uniformly present as to differentiate these tissues as absolutely as any staining. From the base toward the summit, as the seed stems decrease in diameter, the scales increase in size by the enlargement of the cross area of the parenchyma cells, which are usually rounded in section and quite elongate. Beyond the seeds, the cells composing the expanded summits are entirely lignified. In the seed zone, the scales are also more or less lignified and often very thin and flat as they pass between the seeds, where it is sometimes difficult to differentiate them from the seed coats. Exterior to the outer seed stems there is a flattened overlapping series of scales, forming a kind of lateral wall of the fruit several scales in depth. The distal portions of these modified scales are elongate, tetrangular, and lignified, as they appear on the fruit surface.

It is difficult to detect the several elements of the scales in longitudinal section. That some of the xylem cells are spirally marked is certain, and that there is an occasional scalariform marking is also certain. The woody elements of these scales regularly take their origin below that of the cells of the xylem zone of the seed stems, and in figure 5, Plate VIII, are seen extending down into the parenchymatous cushion as small projecting brushlike groups.

It need scarcely be pointed out that there is an analogy between these scales and the central bundle of the seed stems, the variation being in a uniformly large central strand, the addition of a broken subepidermal layer with apical sclerotization, and the presence of occasional ducts in the case of the scales.

The Seeds.—The seeds thus far observed in the present and other species show much variety of preservation. Their study is therefore a difficult one, requiring time, especially for the

purpose of comparing a large number of the same and different species, and determining how far the structures supplement each other. Hence no detailed account of seed structure will be now attempted, although the appended figures, which in reality are but little diagrammatic, are introduced.

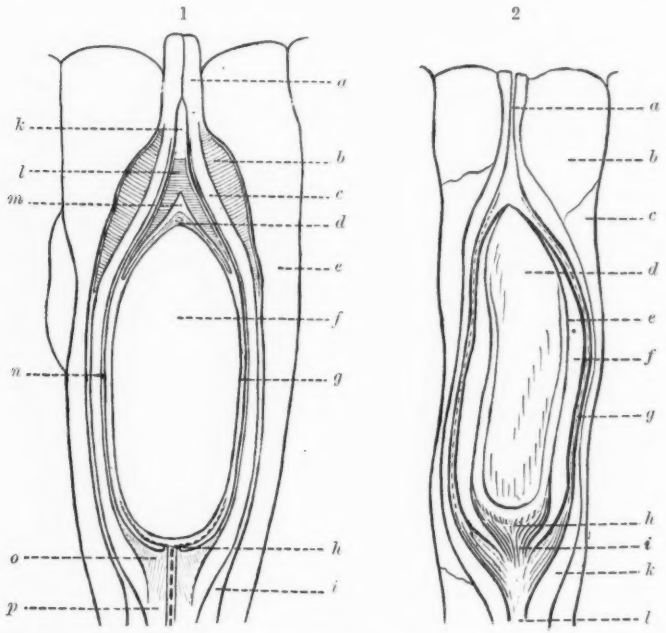


FIGURE 1.—*Cycadeoidea* (*Bennettites*) *Morièrie*, Saporta ♀; longitudinal section of seed. (After Lignier.)

a, micropylar tube; *b*, prismatic layer; *c*, pulpy tissue; *d*, corpuscular mass; *e*, interseminal scales; *f*, embryo space; *g*, remains of nucellus, *h*, chalaza; *i*, tubular layer (= xylem zone); *k*, micropylar canal; *l*, nucellar beak; *m*, pollen chamber; *n*, fibrous stratum; *o*, basal expansion of *n*; *p*, parenchyma of seed stem.

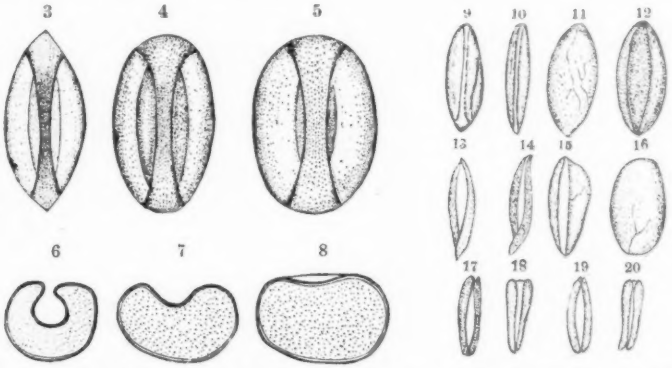
FIGURE 2.—*C. Wielandi*, Ward ♀; longitudinal section of seed. × 12

a, micropylar tube; *b*, interseminal scale; *c*, the same; *d*, cotyledons; *e*, fibrous layer ending below the chalaza in an expanded base of scalariform tissue; *f*, a structureless zone; *g*, stringy remains of cells lignified and slightly expanded below; *h*, chalaza; *i*, woody scalariform tissue; *k*, prismatic outer layer of seed ending in xylem zone; *l*, parenchyma.

General Considerations.

Owing to the large number of male and female examples of *Cycadeoidea* in the Yale collection, their proper correlation will require considerable time. Nevertheless, several facts of im-

portance present themselves for mention. A number of species bear fruits of the type represented in the well-known figure of *C. etrusca* given by Capellini and Solms-Laubach (Plate IV).[10] These heart-shaped fruits have very closely set, rodlike seeds arranged prismatically on a short, fleshy axis, traversed by numerous gum ducts and usually devoid of the regularly arranged seed stems and interseminal scales characterizing *C.* (*Bennettites*) *Gibsonianus*, *C. Morièrie*, and *C. Wielandi*. Should there prove to be no intervening forms and no connection during developmental stages, this must be finally regarded as a strong generic difference. One of the Yale specimens not yet fully studied, but nearly related to *C. etrusca*, as far as may be judged from general features, displays seeds with well-marked cotyledons, as represented in figure 7, Plate IX. Another closely related trunk, of which the female form also is known, shows well-preserved male cones of essentially the same character as those described in Part I of these contributions. Pollen grains, both distended and dessicated, and represented in figures 9–16, are present in rare preservation. They are so like the dissociated pollen figured by Capellini and Solms-Laubach[10] in their description of *C. etrusca* that figures 17–20 in the text are introduced for comparison, as well as pollen from the living cycad *Ceratozamia*, figures 3–8. That these fossil bodies represent characteristic cycad pollen is beyond all question. Sections of the cycadeoidean cone from which the pollen of figures 9–16 was derived are given in figures 17 and 18, Plate X.



FIGURES 3–8.—*Ceratozamia longifolia*, Miquel; pollen grains. (After Juranyi.) × 610.
3, mature pollen in dry condition; 4, 5, the same swollen in water; 6–8, the respective transverse sections, or end views.
FIGURES 9–16.—*Cycadeoidea*, sp., Black Hills; pollen grains. × 250.
9, 10, 13–15, more or less dessicated grains; 11, 12, 16, normal forms.
FIGURES 17–20.—*Cycadeoidea etrusca*, Capellini and Solms-Laubach; isolated and dried pollen grains. (After Capellini and Solms-Laubach).

But one interpretation of these facts is possible—*Cycadeoidea etrusca* represents a fertilized diœcious plant, the male flower of which has now been definitely recognized in an allied species. The so-called "antheriferous tissue" noted by Capellini and Solms-Laubach hence remains an unexplained structure, possibly of much significance. Should this tissue represent a developmental stage instead of permanent structure, as certain sections made by the writer suggest, it nevertheless merits the closest examination, and may have some connection with a "corona" such as that of *Williamsonia gigas*.

Another close resemblance between the American and European species having prismatic seeds is the characteristic surface sculpturing. Figure 2, Plate VIII, is introduced here for comparison with a Bennettitean specimen illustrated by Seward (Fossil Plants of the Wealden, Plate XV, figures 5 and 6).*

Yale Museum, New Haven, Conn., April 24, 1899.

EXPLANATION OF PLATES.

PLATE VIII.

FIGURE 1.—*Cycadeoidea Wielandi*, Ward ♀; type specimen. × ¼.

FIGURE 2.—*Cycadeoidea* (sp.) ♀; surface sculpturing of a fruit. × 10.

FIGURE 3.—*Cycadeoidea Wielandi*, Ward ♀; portion of a trunk, showing scars left by the shedding of fruits. × ¼.

FIGURE 4.—*Cycadeoidea turrita*, Ward ♀; transverse section of a seed stem (from near the parenchymatous cushion) surrounded by an unusual number of interseminal scales. × 30.

FIGURE 5.—*Cycadeoidea Wielandi*, Ward ♀; longitudinal section through seed stems, showing their origin on the parenchymatous cushion. × 24.

FIGURE 6.—Same fruit as figure 5; transverse section of seed stems near periphery of fruit. × 30. (Compare with figure 14.)

PLATE IX.

FIGURE 7.—*Cycadeoidea* (sp.) ♀; nearly transverse section through the periphery of a fruit, cutting 5 seeds, in several of which the cotyledons may be seen. × 16.

FIGURE 8.—*Cycadeoidea Wielandi*, Ward ♀; longitudinal section through a fruit near the summit, cutting superimposed seeds. × 12.

FIGURE 9.—*Cycadeoidea Wielandi*, Ward ♀; type specimen; transverse section through fruit; showing seeds, seed stems, and interseminal scales. × 4.

FIGURE 10.—Same fruit as preceding; longitudinal section through seed stems and parenchymatous cushion. × 4.

FIGURE 11.—*Cycadeoidea turrita*, Ward ♀; transverse section through fruit, cutting a single seed obliquely. × 25.

FIGURE 12.—Same fruit as preceding; longitudinal section. × 4.
a, seed; *b*, densely set interseminal scales and aborted seed stems (?); *c*, the parenchymatous cushion; *d*, involucral bracts; *e*, line of dehiscence (?).

* In the case of generic and specific names, the writer has followed Prof. Lester F. Ward of the U. S. National Museum, as the recognized authority on American cycads. Fortunately for scientific uniformity, Prof. Ward has described practically all the cycads discovered in this country.

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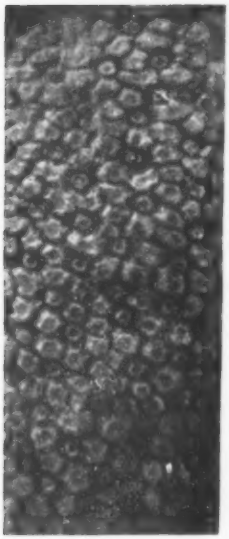

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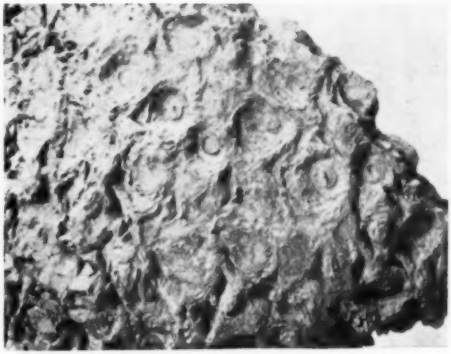

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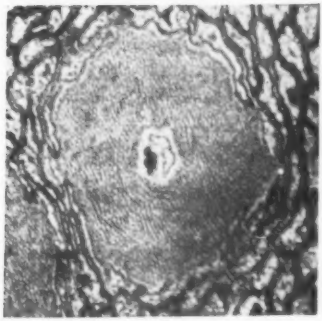

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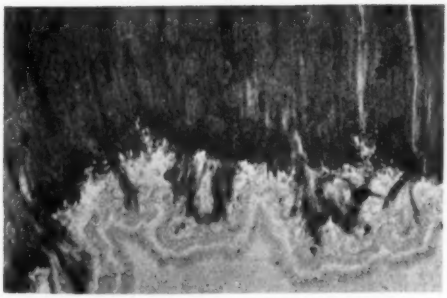

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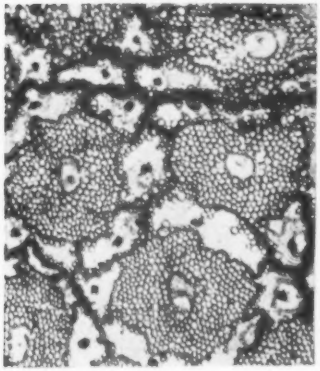

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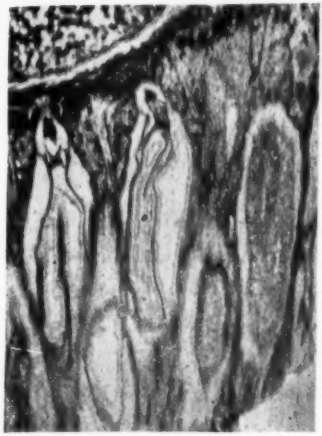

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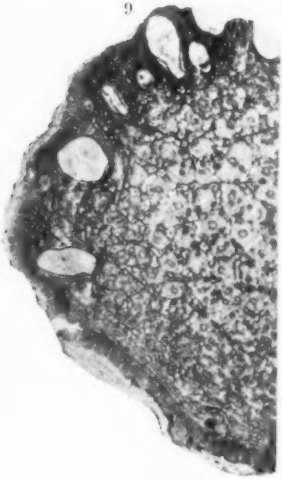

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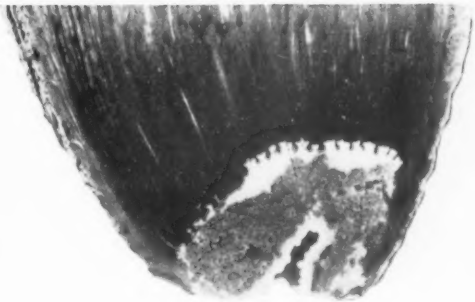

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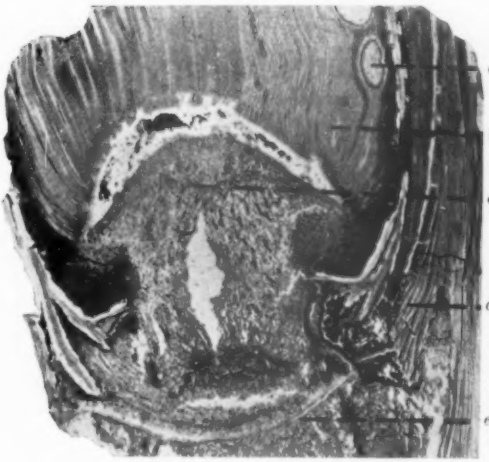

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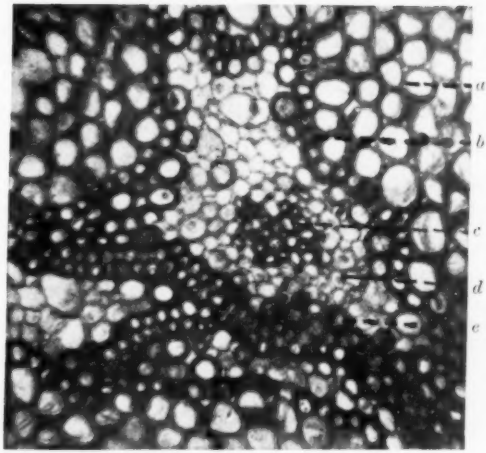

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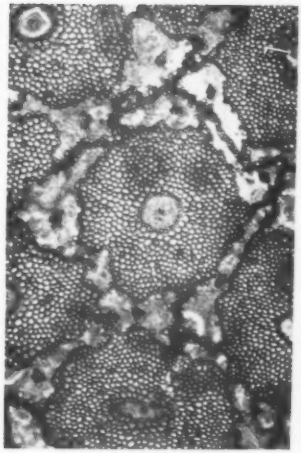

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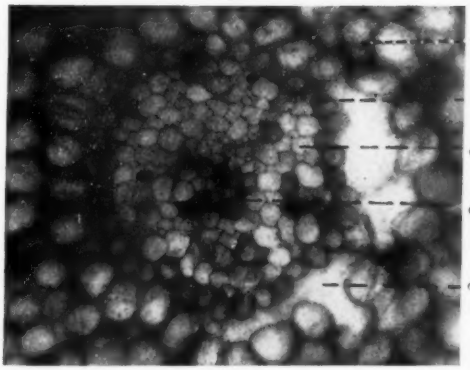

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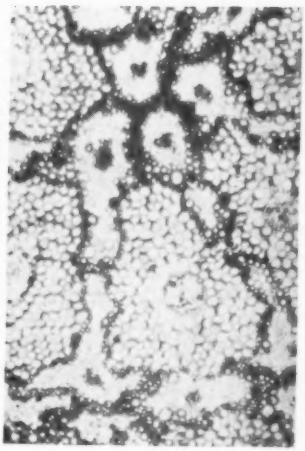

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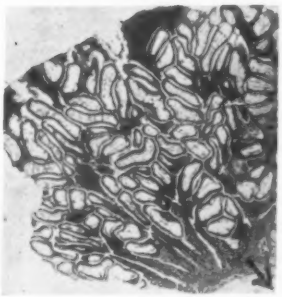

PLATE X.

FIGURE 13.—*Cycadeoidea Wielandi*, Ward ♀: transverse section of an interseminal scale. × 185.

a, xylem zone of a bordering seed stem; *b*, epidermis of the interseminal scale; *c*, xylem; *d*, parenchyma; *e*, heavy and much broken subepidermal layer.

NOTE.—Where two scales border there is a double layer of *b*.

FIGURE 14.—*Cycadeoidea Wielandi*, Ward ♀; type specimen: transverse section through seed stem and surrounding interseminal scales, no parenchyma of either of these organs being preserved. × 22.

FIGTRE 15.—Same fruit as figure 13; transverse section through the central bundle of a seed stem. × 185.

a, xylem zone; *b*, endodermis; *c*, parenchyma; *d*, xylem; *e*, cellular interspace.

FIGURE 16.—Same fruit as preceding; transverse section of seed stems and interseminal scales, all elements being preserved. × 22.

FIGURE 17.—*Cycadeoidea* (sp.) ♂; transverse section through the pendent sori of a sporophyll. × 18.

a, epidermis of prismatic cells which entirely invests each sorus, the latter consisting of two parallel rows of sporangia; *b*, one of the sporangia containing pollen grains as illustrated in text, figures 7–14, page 389.

FIGURE 18.—Same as preceding, but showing a larger area. The arrow points towards the floral axis. × 3.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On Low Temperature Experiments.*—In consequence of the easy production of liquid oxygen and nitrogen in recent times, experiments at low temperatures have become common. Hempel has called attention to the fact, however, that with much simpler means than these, temperatures sufficing for the greater part of the ordinary reactions can be secured. Thus, for example, liquid carbon dioxide, now commercially very cheap, may readily be employed to show that potassium and bromine no longer react on each other at low temperatures. If the bromine be first placed in a mixture of solid carbon dioxide and ether and thoroughly cooled, and then a piece of potassium, cooled in a similar bath, be introduced into it in a small spoon, no combination takes place; though it speedily sets in as the temperature of the mixture rises. Very considerable improvements, however, are necessary in the methods of manipulation. The double-walled and exhausted globe of Dewar, therefore, has been of great service. But these Dewar globes are costly and fragile when they are of large size; and hence are not available for laboratory experiments on any large scale. The author therefore has experimented to determine to what extent a sufficient isolation can be secured in other ways. Test tubes 4^{cm} in diameter, approximately of the same size as the Dewar tubes, were placed in beakers 13^{cm} in diameter, the space between being packed with the material to be tested. Equal quantities of solid carbon dioxide and ether were placed in each of these tubes; so that at the beginning of the experiment all the vessels contained equal quantities of material at $-79°$. From time to time the temperature in the several tubes was determined by an electric pyrometer. In 5 minutes the tube packed with cotton had a temperature of $-76°$, that with wool $-77°$, that with eider-down $-78°$, and that with a well exhausted Dewar tube $-77°$. After 58 minutes these values were successively $-56°$, $-64°$, $-67°$, and $-54°$; thus showing that well dried wool and eider-down are very good insulators, being exceeded only by the best Dewar tubes. For preparing the solid carbon dioxide the author prefers a paper funnel with a wide short neck, to the upper edge of which is fastened a cylindrical bag of linen. On clasping the upper portion of this bag about the valve on the cylinder containing the liquid gas, and opening this valve, the solidified gas collects in the bag and may be readily shaken into the funnel. About 270–300 gms. of the solid are obtained from a kilogram of liquid; and since this liquid costs about 15 cents a kilogram, the solid would cost not far from fifty cents a kilogram. No advantage in yield was found to result on cooling the liquid before expansion. The lowest temperature is obtained when the solid carbon dioxide is mixed with

ether to a stiff magma.—*Ber. Berl. Chem. Ges.*, xxxi, 2993–7, December, 1898. G. F. B.

2. *On Reductions in Presence of Palladium.*—Although palladium-hydrogen has been used already as a reducing agent by Graham and by Saytzeff, yet now by a more extended study ZELINSKY finds that it may be employed with great success in the reduction of bromides and iodides of cyclic alcohols, a class of compounds which hitherto it has been impossible to reduce by any of the ordinary methods. The form in which it is used is that of a palladium-zinc couple, analogous to the copper-zinc couple of Gladstone and Tribe. To form it, zinc filings are well washed with alcohol, then treated with sulphuric acid until an active evolution of gas takes place, and finally washed with water. On pouring upon them a one or two per cent solution of palladium chloride previously acidified with hydrochloric acid, a thin strongly adhering layer of palladium is deposited upon the zinc. The couple thus formed is washed with alcohol and dried. To effect the reduction, which takes place at the ordinary temperature and up to 100°, a flask provided with a reflux-condenser and dropping funnel is one-third filled with the palladium-zinc couple, this couple is partly covered with methyl or ethyl alcohol and hydrochloric acid saturated at 0° is run in drop by drop. At first the hydrogen is absorbed by the palladium; and as soon as bubbles of gas are evolved, the bromide or iodide to be reduced is added gradually, alternately with the acid. The action is controlled by regulating the quantities of material added. The evolved gases are passed through alcohol to retain any volatile hydrocarbon which may be carried over. The palladium-zinc in the flask, after washing with acid and with alcohol, is ready for further use.—*Ber. Berl. Chem. Ges.*, xxxi, 3203–5, January, 1899. G. F. B.

3. *On the Properties of Metallic Calcium.*—Further results have been communicated by MOISSAN on the properties of calcium. Prepared by the method already described,* the metal separates from fused sodium in hexagonal crystals which have a specific gravity of 1·85 and melt at 760° in vacuo. On solidifying, the metal is somewhat brittle, is less malleable than potassium or sodium and shows a crystalline fracture. When free from nitride, it is silver-white in color and has a brilliant surface. Heated to redness in a current of hydrogen, a crystalline hydride CaH_2 is formed. When pure, calcium is not acted on at ordinary temperatures by chlorine; though at 400° the action is decided. But if the metal contains nitride, chlorine attacks it at the ordinary temperature. At 300° it ignites and burns brilliantly in oxygen. Gently warmed in air, it burns with brilliant scintillations. It combines with sulphur at 400° with incandescence. At a red heat it unites actively with lamp-black, yielding CaC_2. Calcium gives somewhat brittle alloys with magnesium, zinc and nickel. With tin the alloy contains 3·82 per cent of calcium, has a density of 6·70, and slowly decomposes water. A crystalline amalgam is

*This Journal, IV, vi, 428, November, 1898.

formed with mercury which may be distilled in hydrogen at 400°, but which forms nitride when heated in nitrogen. Heated to redness with potassium or sodium chloride, calcium sets the metal free. Water acts on calcium only very slowly, evolving hydrogen. At a red heat, it combines explosively with phosphoric oxide, and decomposes silica, yielding calcium silicide and some silicon. At 600° it reduces boric oxide to boron. Nitric acid when strong acts on calcium very feebly, though when diluted the action is rapid. Fuming sulphuric acid is reduced by the metal. Heated to dull redness in ammonia, a mixture of hydride and nitride is produced. In liquefied ammonia at −40°, calcium ammonia is formed, a reddish brown solid.—*C. R.*, cxxvii, 584–590, October, 1898. G. F. B.

4. *On New Bases from Strychnine.*—It has been noticed by TAFEL that when a current of five amperes at a potential of three and a half volts is passed through a solution of 30 grams of strychnine in 180 grams of concentrated sulphuric acid diluted with 120 grams of water, two poisonous bases are produced which he calls tetrahydrostrychnine and strychnidine. After passing the current for two hours, the liquid, diluted with four volumes of water, is nearly neutralized with barium carbonate, filtered, heated to boiling and treated with barium hydrate in slight excess. The strychnidine is contained in the precipitate while the filtrate contains the tetrahydrostrychnine. Strychnidine crystallizes from alcohol in stellate groups of colorless needles, fusing in vacuo at 252° and having the structural formula $C_{20}H_{22}NO\begin{matrix}CH_2\\ \diagup\\ \diagdown\\ N.\end{matrix}$ It boils at 290°–295° under 14^{mm} pressure, and may be distilled undecomposed, the distillate solidifying to a crystalline mass. It is sparingly soluble in water, but dissolves more freely in alcohol, benzene and chloroform. A 6·4 per cent chloroform solution has a specific rotatory power $[\alpha]_D = -8{\cdot}28°$ at 20°. Dissolved in sulphuric acid, it gives color with oxidizing agents. Its aqueous solutions with excess of acid become intensely red with potassium dichromate, hydrogen peroxide, ferric chloride and sodium nitrite. Tetrahydrostrychnine $C_{20}H_{22}NO(NH).CH_2.OH$ crystallizes from alcohol in colorless prisms, containing a molecule of the solvent, which it loses at 100°. It dissolves in 280 parts of water at 20°, the solution being strongly alkaline. It resembles strychnidine in its action with sulphuric acid and oxidizing agents, but gives a wine-red solution when its hydrochloric acid solution is treated with chromic acid or ferric chloride. Strychnoline, obtained by reducing dioxystrychnine in amyl alcohol with sodium, and dihydrostrychnoline, produced by passing a current through a solution of deoxystrychnine in sulphuric acid, are also described.—*Liebig's Annalen*, cccl, 285–348, August, 1898. G. F. B.

5. *A History of Physics in its Elementary Branches including the Evolution of Physical Laboratories;* by FLORIAN CAJORI,

Ph.D. 8vo, pp. viii, 322. New York, 1899 (The Macmillan Company).—In this book the author has attempted a somewhat condensed review of the progress in physical science from the earliest times to the present. In the preface he quotes Ostwald's statement to the effect that a defect attaching to present scientific education is the absence of the historical sense and the want of knowledge of the great researches upon which the edifice of science rests. It seems to be fully recognized that the historical development of a subject is an essential aid to the proper understanding of it. It may be a question, however, whether this historical treatment should not be given in connection with the subject discussed rather than have a separate course devoted to it. In this book the history of physics is divided into time epochs, i. e., that of the Greeks, the Romans, the Arabs, the Middle Ages, the Renaissance, the Seventeenth Century, the Eighteenth Century and the Nineteenth Century; closing with a chapter on the Evolution of Physical Laboratories. This method seems to necessitate considerable repetition, light for example being considered six times. Possibly a physical classification would entail less repetition and be handier for reference. A wide range of references has been made use of and these are given in foot-notes. The book will undoubtedly be of use to students and teachers of physics, for whom it was intended.

6. *The Electrolytic Interrupter.*—Much interest has been excited by Dr. A. Wehnelt's new interrupter for induction coils, which consists of a lead plate, the cathode, and a platinum point, the anode, immersed in dilute sulphuric acid and connected with an electrical source of comparatively high voltage. At a recent meeting of the Physical Society in London, March 10, Mr. A. A. Campbell Swinton described his experiments with this interrupter. It was found that the minimum working voltage was twenty-five volts. The spark-pitch varied with the length of the platinum terminal wire. The wire must be immersed in the dilute acid before the circuit is closed, otherwise the action is not obtained. The interrupter becomes fatigued in a quarter of an hour and then the platinum becomes red-hot. The interrupter would be very effective for X-ray work if it did not heat the Crookes tubes. Mr. Swinton suggested the use of the interrupter for the production of Hertz waves. Professor Oliver J. Lodge thought that it would not be effective for this purpose since the air would not quickly regain a non-electric condition. The interrupter will work with an alternating current but with half the efficiency, apparently allowing only one-half the alternations to pass. A well-known arrangement, however, of circuits might give a greater efficiency.—*Nature*, March 16. J. T.

7. *Measurement of slow electrical oscillations.*—W. König discusses previous methods of receiving the sparks from an induction coil on lamp-blacked rotating discs, and describes an efficient method of measure, which consists of a tuning fork provided with a stylus which serves both to register the time on a blackened

disc connected with a pendulum and to serve as a terminal to deliver the spark to the moving disc. With this apparatus he finds that he can follow changes of potential under twenty volts. He finds that the electrostatic capacity of the bobbin of the induction coil is of the order 16×10^{-12} farad. The working of the iron core of the coil diminished with increasing number of vibrations.— *Wied. Ann.*, No. 3, 1899, pp. 535–562. J. T.

8. *Electric waves on wires.*—W. D. COOLIDGE has succeeded in photographing electric waves on wires by using a vigorous exciter—Blondlot, or Tesla transformer. The photographic lens was placed above the wires, which were horizontal. The nodes and ventral segments are clearly distinguished in the photographs. — *Wied. Ann.*, No. 3, 1899, pp. 578–591. J. T.

9. *Absorption of the X-rays by air.*—Since very short ultra-violet waves of light are absorbed by air, it is an interesting question to consider the absorption of the X-rays by air. Some recent experiments by Prof. Trowbridge and Mr. J. E. Burbank in the Jefferson Physical Laboratory instituted to study this question show that the difference of absorption of a column of air thirty inches in length at atmospheric pressure and a column of air of the same length at four millimeters pressure cannot be distinguished by the use of a fluoroscope. With cathode rays the difference is as thirty-three to one. That is, the absorption is thirty-three times as much in air at atmospheric pressure as at four millimeters pressure. The electrostatic effects in the exhausted tube thirty inches long are very beautiful and cease when the concave mirror of the X-ray tube becomes the positive terminal. J. T.

10. *Die Optischen Instrumente der Firme R. Fuess; deren Beschreibung, Justierung und Anwendung* von C. LEISS; pp. xiv, 397, with 233 text figures and three photo-plates. Leipzig, 1899 (Wm. Engelmann).—Very important advances have been made within recent years in the methods and apparatus applicable to crystallographic and optical investigations. The present volume, giving an account of the instruments furnished by the firm of R. Fuess (Berlin), is very thorough and complete and will be of great value to all working in this field. There are described here, for example, a number of forms of spectrometers and various types of apparatus to be used with them, as, for example, the new spectral arrangement of Wülfing, giving homogeneous light of different wave lengths. The reflectometers, spectrographic apparatus, goniometers, microscopes, are also fully and minutely treated of. The chapter giving an account of the different forms of apparatus for projections with electrical lamps is particularly interesting and timely. The volume is not simply a catalogue of instruments, but gives full descriptions of the method of use applicable in each case, with references to the original papers. The worker is thus told not only what instruments are to be had, but when he is supplied with them, how they are to be adjusted and used in practical investigations.

II. Geology and Natural History.

1. *Note on a Bridger Eocene Carnivore;* by O. C. Marsh.*—A reëxamination of the three species of the genus *Limnocyon* described by me in 1872 (this Journal, vol. iv, pp. 122, 203, and 204), leads to the conclusion that the type is in all probability to be referred to the genus *Sinopa*, Leidy, from the same horizon. While this statement applies to *Limnocyon verus*, the species first described, yet a second species of the genus, *Limnocyon riparius*, described by me in the paper cited, is undoubtedly distinct, and cannot be placed in any known genus of Eocene Carnivora. Since the type species of the genus, however, is thus shown to belong to *Sinopa*, the generic name *Limnocyon* must be abandoned and another substituted. I therefore propose the name *Telmatocyon*, basing the genus on the remains referred to *Limnocyon riparius*.

The generic characters may be stated as follows:

Dentition: $I\frac{3}{3}$, $C\frac{1}{1}$, $Pm\frac{4}{4}$, $M\frac{2}{3}$; two lower molars subequal in size and tuberculo-sectorial in pattern; internal cusps of these teeth considerably reduced, as in *Sinopa;* jaw very straight on inferior border, not unusually deep, but relatively thick and heavy, symphyseal portion abrupt and robust; first superior molar with external cusps well separated, and not closely approximated as in *Sinopa*.

This genus thus differs from the contemporary *Viverravus*, in the unreduced condition of the second lower molar as well as in the character of the jaw; from *Vulpavus*, in having two instead of three lower molars; and from *Sinopa* as already indicated.

2. *The Age of the Franklin White Limestone of Sussex County, New Jersey;* by John Eliot Wolff and Alfred Hulse Brooks, Eighteenth Annual Report of the U. S. Geological Survey, 1896–97, Part II, pp. 425–457, 1898.—Messrs. Wolff and Brooks have made a careful study of the white limestone of Sussex County, which, with the blue limestone of the same region, has been the subject of many papers of those attempting to determine the age of the limestones. Mr. Nason, in 1890, gave at the time what seemed to be conclusive evidence of the Cambrian age of the white limestone, attributing its crystalline condition to the intrusion of igneous rocks, and also maintained that the white and blue limestones passed one into the other. The present writers have reached the conclusion that the white limestones are pre-Cambrian in age, and that the quartzite and blue limestone are Cambrian. Their conclusion regarding the relationship of these is as follows: "That the white limestone was deformed and metamorphosed to its present condition and partly eroded before the basal member of the Cambrian series was laid down; that the

* This note was prepared by Dr. J. L. Wortman, who first called Professor Marsh's attention to the points of synonymy as here given. The matter was left incomplete at the time of Professor Marsh's death.—Ed.

deformation which the area has suffered since the deposition of the Cambrian, which has manifested itself in folding and faulting, has been but slight compared with the pre-Cambrian deformation ; and that the Cambrian rocks overlie the white limestone, as well as the gneisses, unconformably. As a result of our observations, we are compelled to adopt the pre-Cambrian age of the Franklin white limestone." H. S. W.

3. *West Virginia. Geological and Economic Survey.*—Professor I. C. White, the State Geologist, has issued a map of West Virginia, compiled by Russell L. Morris, C.E., on the scale of 10 miles to the inch, on which are given the location of oil pools, natural gas wells, and the approximate distribution of the New River, Alleghany or Kanawha River, and Pittsburg coal areas. The map is not complete, but is issued as a preliminary one only. H. S. W.

4. *Alabama Geological Survey. Iron-Making in Alabama. Second edition ;* by WILLIAM BATTLE PHILLIPS, pp. 1–380, 1898.—This is a second edition of the report published in 1896, containing new statistics regarding the products of the State. Several new chapters have been added, among them additional information as to the coal industry, compiled from the report by James D. Hillhouse, State mine inspector. H. S. W.

5. *The Development of Lytoceras and Phylloceras,* by JAMES PERRIN SMITH, Pro. Cal. Acad. Sci., 3d Ser., Geol., vol. i, pp. 129–160, plates xvi–xx, 1898.—The two genera Lytoceras and Phylloceras are chiefly interesting "because they are simple, unspecialized genera, long-lived, little changed, and yet with the power of giving off other variable branches. They are the two longest-lived genera of ammonites, ranging from about the end of the Trias to the Upper Cretaceous, at least seven millions of years by a conservative estimate." The author has prepared beautiful plates illustrating the sutures of the protoconch and following stages of growth ; and concludes from his studies that "these two genera come from a common origin, and follow the same paths up to *Nannites*, where they part company, each going through a stage corresponding to that genus, but to different species under it; both go through *Monophyllites* stages, but here again analogous to different groups and even different subgenera. There the resemblance ceases, and they develop into different families probably by the middle of the Trias, for in the upper division of that formation *Megaphyllites* and *Monophyllites* are sharply distinguished from each other. In the life-history of these two genera we have a rare opportunity of observing acceleration of development, and divergence of two nearly related stocks, whose history may be traced from the Paleozoic to near the end of the Mesozoic eras." H. S. W.

6. *Pre-Cambrian Igneous Rocks of the Fox River Valley, Wisconsin ;* by S. WEIDMAN (Wis. Geol. and Nat. Hist. Surv., Bull. III, Science, Series 2).—This is a geologic and petrographic description of three areas of igneous rock, which appear to have been islands during the deposition of Cambrian sediments. They consist of an ancient rhyolite, a rhyolite changed to gneiss and a

granite, which probably represent phases of a parent magma. The various changes induced in these rocks through mechanical deformation in two of the areas and through chemical alteration alone in the third have been carefully studied and many features of interest are developed. L. V. P.

7. *West Virginia Geological Survey*, vol. 1; by I. C. WHITE, State Geol. (Morgantown, West Va., 1899, 8°, 392 pp.)—In addition to the administrative report this volume contains a discussion of magnetic declination for the state with description of meridian monuments by R. U. GOODE. The State Geologist himself contributes a list of levels above tide and a particularly valuable report on the petroleum and natural gas of the state. This is treated both from theoretic and practical standpoints and will be found of great service to those engaged in a study of these products. It is to be hoped that the state will continue the survey and permit the publication of other valuable material which has been accumulated. L. V. P.

8. *A new and interesting olivine-melilite-leucite rock.*—The rock of one of two small volcanic cones discovered by E. Clerici at San Venanzo in Umbria, about half way between Orvieto and Perugia, has been described by V. SABATINI in a note (dated September, 1898) in the Bolletino del Reale Comitato Geologico for 1898, as a leucitic melilitite with olivine. Olivine occurs as phenocrysts, and the groundmass is composed of melilite, leucite, black mica, and a little pyroxene, nephelite and magnetite, feldspars being absent. The melilites are zonally built, the interior being optically positive and the exterior negative. Sabatini proposes for this type the name *Venanzite.*

At the meeting of the Berlin Academy of Sciences held Feb. 9, 1899 (Sitzungsberichte, vii, p. 110, 1899), Prof. Rosenbusch read a paper on "Euktolite, a new member of the theralitic effusive magmas." This rock is identical with that of Sabatini, coming from the same locality, and his description is practically the same though more detailed, and with chromite and perofskite added to the list of component minerals. An analysis gave:

SiO_2 41·43, TiO_2 0·29, Al_2O_2 9·80, Fe_2O_3 3·28, FeO 5·15, MgO 13·40, CaO 16·62, Na_2O 1·64, K_2O 7·40, H_2O 1·11 = 100·12. P_2O_5 none. Sp. gr. = 2·758.

He compares it with the madupite of Cross, leucitites, and leucite and melilite basalts, all of which belong to his theralitic magmas. The name is derived from εὐκτός, desired, since it is "a desired example for the validity of my representation of the intimate connection of the eruptive rocks throughout the world." Sabatini's name Venanzite antedates Euktolite by about five months and on the grounds of priority is unquestionably the one by which this interesting type should be known, especially since it is formed from the type locality, in accordance with modern usage in petrography, and does not involve the tacit acceptance of any theory, however generally recognized.

H. S. W.

9. *Deuxième Mémoire sur les Algues Marines du Groenland;* by L. KOLDERUP ROSENVINGE. Meddelelser om Gronland, xx, pp. 1–125, pl. i and 25 figs., 8°. Copenhagen, 1898. *Om Algenegetationen ved Grønlands Kyster;* ditto, pp. 131–242.—The paper first named is an important supplement to the author's Groenlands Havalger published in 1893. The material studied included the collections made by N. Hartz, principally at Scoresby Sound during the expedition to East Greenland under Lieut. Ryder and those made by A. Jessen and C. Ostenfeld in West Greenland, besides a few smaller collections. Of the algæ of the eastern coast, which had been less thoroughly explored than the western, only 32 species had been previously enumerated, but in the present work the number is estimated at 82 including several new species. The number of species previously known on the west coast was 143, which number is now increased to 167 including in the enumeration the species reported by Kuckuck from Umanak collected by Vanhoffen. The Lithothamnia were revised by Foslie. Among the novelties are three new genera, Ceratocolax, Dermatocelis and Arthrochœte, each represented by a single species of parasitic habit. The paper is well illustrated and the notes are full and suggestive. The second paper by Dr. Rosenvinge is a valuable contribution to our knowledge of the distribution of the marine floras of the North Atlantic, which gives details as to the temperature and other factors which affect the growth of marine plants and tables showing the relations of the Greenland flora to those of northern Europe and the Atlantic coast of North America. In spite of the remoteness and inclemency of the Greenland coast, thanks to the publications of Rosenvinge, Kjellman and other Scandinavian algologists, its marine flora is more accurately known than that of any other portion of the Atlantic coast of America. W. G. F.

10. *Monographie des Caulerpes;* by Mme. A. WEBER-VAN BOSSE, Ann. Jardin Bot. Buitenzorg, xv, pp. 243–401, pl. xx–xxiv.—In a short introduction the author gives a summary of what is known regarding the cell structure with notes as to the probable fructification of the species of this large and peculiar genus, for, in spite of their abundance and wide distribution in all warm seas, no one has as yet succeeded in detecting with certainty their method of reproduction. The monograph is essentially a systematic study of the species for which the author is especially well qualified, since her excursions to the tropics have given her abundant opportunity for observing the Caulerpae in a living condition, while, on the other hand, she has been able to examine the dried specimens of practically all of the large algological herbaria. The subdivisions of the genus adopted are those of Prof. J. G. Agardh, but the number of species recognized by Mme. Weber is considerably smaller than in other works on the genus. In thus uniting the older described species the author, we think, has shown good judgment, and her excellent presentation of the subject gives a much better view of the genus

as a whole than has been possible to obtain hitherto. Especially in her treatment of the Thuyoideae and Claviferae is the author to be commended. One is at first struck by the very large number of species reduced to synonyms under such species as *C. cupressoides* and *C. racemosa*, which latter name replaces *C. clavifera* as generally used hitherto. But one who has had the opportunity of examining large sets of specimens can hardly fail to approve the specific limitations adopted by the author, for not only are the species themselves very variable but, also, one more than suspects that many of the species previously described owed their assumed characters to some accident of preparation. The arrangement of the present monograph seems to us to be the natural one and one which is likely to be generally adopted.

W. G. F.

11. *De dispositione Delesseriearum;* by Prof. J. G. AGARDH, pp. 239, 8°, Lund, 1898.—This volume, which forms the third part of the third volume of the classic *Species Genera et Ordines Algarum*, of which the first volume appeared in 1848, is a rare illustration of continued scientific activity in a field in which the writer has been a master for more than sixty years. To American algologists it is of special interest, as it includes a revision of the species of Nitophyllum, Delesseria and related genera from our Pacific coast which were originally described in Agardh's Epicrisis and subsequent memoirs, to which are added *Nitophyllum macroglossum*, *N. stenoglossum*, *N. marginatum*, *N. Farlowianum*, *Neuroglossum lobuliferum*. The new genus Erythroglossum with five species includes *Delesseria Woodii* and *D. Californica*, and *Apoglossum* includes *D. dicipiens*, all three Californian species. The new genus Calloseris is founded on a single species, *C. Halliae*, from Florida. W. G. F.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *National Academy of Sciences.*—The spring meeting of the National Academy was held in Washington from April 18 to 20. The following gentlemen were elected members: Charles E. Beecher of New Haven; George C. Comstock of Madison; Theodore W. Richards of Cambridge; Edgar F. Smith of Philadelphia; Edmund B. Wilson of New York. The list of papers accepted for reading is as follows:

W. K. BROOKS and CASWELL GRAVE: Ophiura Brevispina.

A. HALL: The shadow of a planet.

A. AGASSIZ: On the Tanner deep-sea tow net. On the diamond and gold mines of South Africa.

A. AGASSIZ and A. G. MAYER: On the Acalephs of the East Coast of the United States.

E. C. ANDREWS: On the limestones of Fiji.

W. McM. WOODWORTH: On the Bololo of Fiji and Samoa.

CHAS. D. WALCOTT: Progress in surveying and protection of the U. S. Forest Reserves.

GIFFORD PINCHOT: The work of the Division of Forestry, Department of Agriculture.

H. S. PRITCHETT: The resulting differences between the astronomic and geodetic latitudes and longitudes in the triangulation along the Thirty-ninth Parallel.

A. GRAHAM BELL: On the development by selection of supernumerary mammæ in sheep. On kites with radial wings.

S. NEWCOMB: Remarks on the Work of the Nautical Almanac Office during the years 1877–98 in the field of Theoretical Astronomy.

W. K. BROOKS and L. E. GRIFFIN: Exhibition of specimens of *Nautilus pompilius*.

The third memoir of volume viii of the Memoirs of the Academy has recently been issued. The title of the paper is: General perturbations of Minerva (93), by Jupiter, including terms only of the first order with respect to the mass, together with a correction of the elements, by W. S. Eichelberger, Ph.D.

2. *Annual Report of the Board of Regents of the Smithsonian Institution, to July, 1897;* pp. xlvii, 686. Washington, 1898.—The Report of the U. S. Natural History Museum, under the direction of the Smithsonian Institution, for 1896, was noticed in the last number, and we have now issued the Smithsonian Report for 1897. The early portion of this is devoted to an account of administrative matters, by the Secretary, Professor S. P. Langley. This occupies some eighty pages. The remainder of the volume, or General Appendix, contains reprints of a well-selected series of papers on a very wide range of subjects; these include memoirs on astronomy, physics (X-rays, etc.), chemistry and so on through to archæology. The volume closes with an obituary notice of George Brown Goode by S. P. Langley, and one of Francis Amasa Walker by G. F. Hoar and C. D. Wright.

3. *Harper's Scientific Series.*—The recent additions to the series of Harper's scientific memoirs include Volume III, on *Röntgen Rays*, edited by Professor GEORGE F. BARKER of Philadelphia, and Volume IV, on the *Modern Theory of Solution*, edited by Dr. HARRY C. JONES of Johns Hopkins University. The first of these contains the original paper by Röntgen, and also others by Stokes and J. J. Thomson. Each of the papers is followed by a biographical sketch of the author, and the bibliography of the subject is added at the end. This subject is one of very great interest at the present time, and indeed this statement may also be made about Volume IV on the Theory of Solution. This latter contains papers by Pfeffer, Van 't Hoff, Arrhenius, and Raoult, with the usual useful editorial matter.

OBITUARY.

DR. GUSTAV WIEDEMANN, the distinguished physicist, for twenty-two years (1877–1899) editor of the Annalen der Physik und Chemie, died on March 23 at the age of seventy-three.